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ABSTRACT

"Outlook" publications focus on areas of science and technology in which research can be valuable to industry, government, and society as a whole. Their purpose is to point up significant current problems in those areas and to suggest effective research approaches to their solution. This issue, dealing with changes taking place in our schools and total educational system, presents six major essays. The first, "New Schools for New Times," explores designing schools that are responsive to changing demands and focuses on improving student performance. The need for clearly defining what schools want to accomplish is discussed in "Bringing Management by Objectives to Schools." "The Curriculum: Make It Relevant!, Make It Work!" demands the formalizing of precise objectives and instructional goals as a basis for better curricula. The prototype of a practical system for teacher appraisal is spelled out in "Appraising Teacher Performance," while the adoption of a planning--programming--budgeting system is called for in "PPBS: Planning for Schools of the Future." The final article, "A Better School/Community Dialogue," looks closely at the communication programs of educators who are confronted by the public's growing disenchantment and concern with school practices and expenditures. Miscellaneous notes and research briefs complete the publication. (EL)

# *Battelle* Research Outlook

## *The Schools: Organizing for Change*

Volume 2 • Number 2 • 1970

Battelle Memorial Institute - Columbus Laboratories

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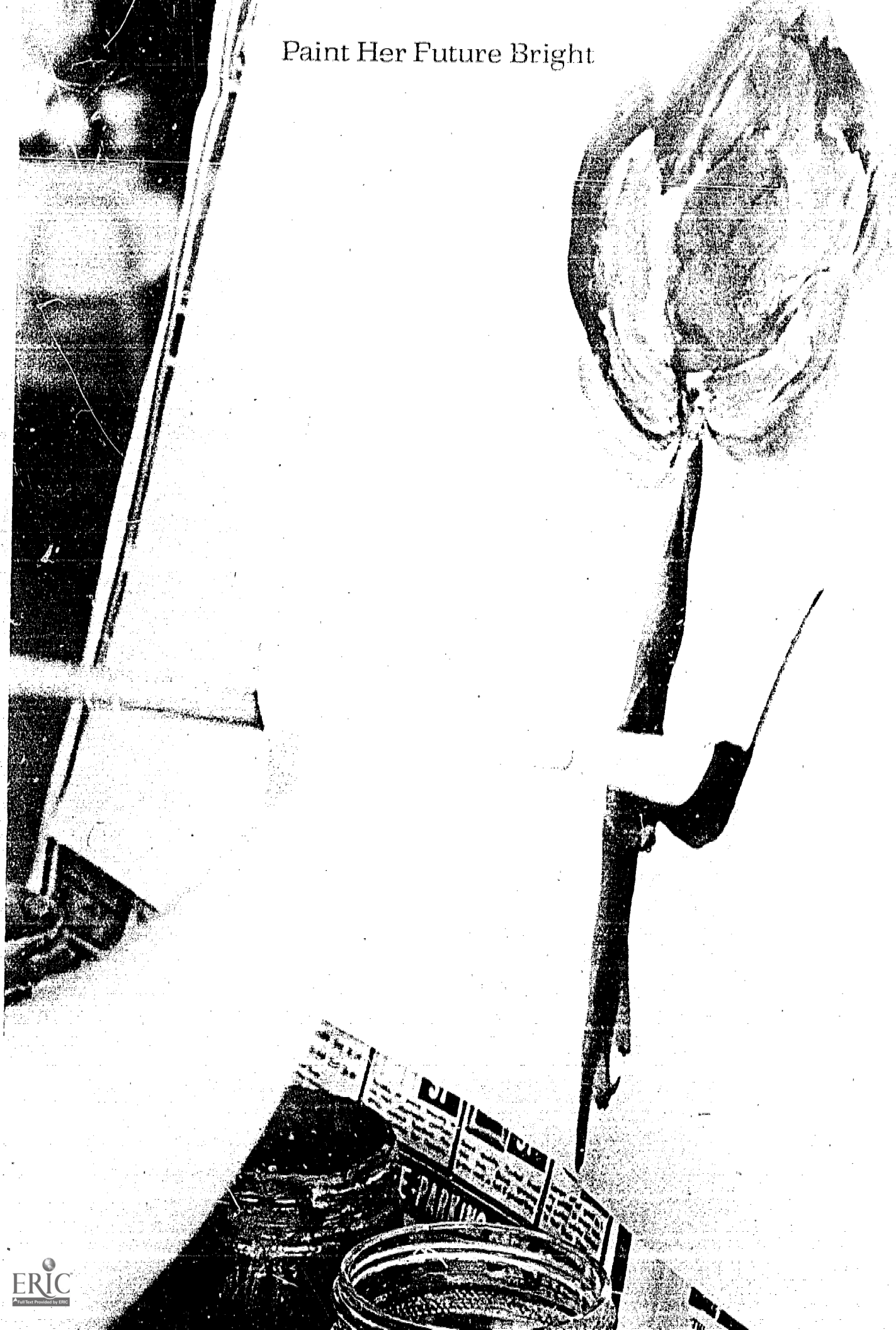
Paint Her Future Bright



# NEW SCHOOLS FOR NEW TIMES

*by David S. Bushnell*

EDUCATION IN THE U.S. is a $55 billion enterprise. One out of every four Americans is directly engaged as a student, teacher, or educational administrator. Many others work in supporting roles or in the growing industry of educational suppliers. The President recently observed that we now spend as much on education as the rest of the world combined.

Education's role in maintaining and enhancing the skill and adaptability of the U.S. labor force and in providing the basis for further growth through research allows us to continue our rate of economic advance in competition with other nations. Economists have recognized that expenditures on education have produced a large share of the economic growth achieved in this country in recent years. Former Labor Secretary George P. Shultz estimated almost a decade ago that the yield from our investment in education since 1929 may account for one-fifth of the rise in national output.

Learning experiences that produce citizens who can adapt to change may well prove to be one of our nation's greatest resources; but ironically, our educational system itself has moved toward rigidity and unresponsiveness to change. How to make it more responsive to new demands and how to renew its ability to serve human needs and the nation's economy are the focal points of this article and those that follow.

Until recently, pressures for educational reform have come largely from outside the establishment. The taxpayers have been complaining more and more about the dollar cost of education. The changes wrought by the advent of a computer-based technology have produced demands for new skills, and employers want employees with these skills. Further, the militant skepticism of the disadvantaged and of many students from more affluent levels of society underscores the fact that educational institutions have not kept pace with the requirements for living and working in the real world.

It has only been in the last decade that efforts to improve schools have been bold enough to try to reform the total educational system. Not many adventurous souls have been willing to wrestle with curriculum content, instructional procedures, teacher functions, and administrative procedures all at the same time. Yet, this is happening in a few places, and with promising results. Harnessing the power of systematic inquiry in behalf of education occupies the attention of a growing cadre of specialists. Their struggles and modest successes are making a story that is well worth the telling. What's happening in education R & D becomes particularly clear when today's situation is viewed from two perspectives: current needs and demands on education, and the promising developments now being pioneered.

## EDUCATION UNDER PRESSURE

Schools are under pressure to change for several basic reasons. The beneficiaries of the system, the students, sense that teachers are out of touch with the real world and its demands. Today's students are a product of a shrinking environment, a world made smaller through TV and travel. Many of the more advantaged commit themselves to social service. Having economic security, they are most concerned with the inequities that they see about them and find their reward in conducting aggressive action on behalf of the disadvantaged.

It seems fair to describe our younger generation as more empirical and involved, and less metaphysical and detached, than the older generations in its orientation to the world. Our youth are doers rather than spectators. Advances in technology, from the H-bomb to the spacecraft and from the pill to the heart transplant, have amplified this generation's sense of power, even over the forces of life. This concern with the empirical—this desire to discover and to use discovery to effect change — has led many students to observe and question the events around them. They want to know, to take active part, and to have an impact.

These characteristics of present-day students naturally engender profound implications for the educational system. Because so many schools operate by keeping students in a subordinate role, some observers characterize our public schools as custodial institutions. Instead, school programs and policies must be developed in a more democratic way with students actively involved in the decision-making process. For too long, school administrators have failed to teach or communicate to the supposed beneficiaries of the system that the traditional practices make sense, if indeed they do. Students are challenging time-worn procedures. They are demanding that teaching methods and learning materials be shaped to meet more of their needs, and not just those of the educators.

The recent success of the documentary film "High School" dramatizes the defensiveness with which students react to their learning environment. The fear of breaking some petty rule, the insistence that students be respectful, and the teacher's instinct for "disrespect" are portrayed vividly.

The relative decline in the availability of employment in the manufacturing sector of our economy and the rise of the service industries also are creating pressures for change. This shift has produced a corresponding rise in the need for writing, listening, speaking, and reading skills. Interpersonal skills, for opening up and maintaining effective communication with consumers or fellow workers, are in considerable demand and have to be acquired somehow during the formative years.

Yet, the products of today's schools reflect little training of this kind. They are likely to have tightly compartmentalized knowledge, with low mastery of verbal skills and little motivation for continuing their learning. Those who fail to live up to the demands of the typical school system come away scarred and

frustrated by education. The joy of discovery is lost in the disillusion of failure.

Another factor that is pressuring the schools is the strong shift from concern about quantitative aspects of education to the matter of quality. In the past two decades, the problem has been to supply buildings and teachers to handle an 80 percent increase in the population of schools, this growth being aggravated by the mass migration to urban and suburban areas. Educators have had all they could do to keep up with the booming numbers. Now this period of rapid growth is over, and the push is shifting to demands for better quality in education.

While emphasis was focused on accommodating more and more students, schools could get by with teaching the same thing, using the same methods, year after year. No more. Now they are faced with the accusation that much of this comfortable tradition has little relation to the problems of operating in today's world. Schools are being prodded to tailor programs to meet the diversified backgrounds, interests, and abilities of the students and their needs in the real world. Middle-class teachers who are teaching irrelevant curricula have little chance of relating positively to individual students, and thus offer slim hopes for bringing about the major reforms needed in education.

Finally, it's getting harder to finance the rising costs of education. Taxpayers who contentedly passed levy after levy for the past 20 years are suddenly putting their foot down — hard. In those years they were willing to take the educator's word that the schools were doing fine; now they are becoming more and more critical of where their dollars go and what those dollars are being used for. To raise money in the future, educators will have to present a much better case than they have in the past.

Part and parcel of the money problem is the structure of school financing. Well over half of the educational budget for public schools is funded by the local property owner, who has begun to bend under the burden. The situation is particularly acute in districts with plateaued or declining tax revenues — especially in many large urban areas, where educational reforms are most needed. Clearly, changes are necessary in the methods of financing public education. Imagine the plight of the airline industry if it were forced to modernize and expand its services without federal assistance *and* the opportunity to write-off operating losses.

## THE SYSTEM'S RESPONSE

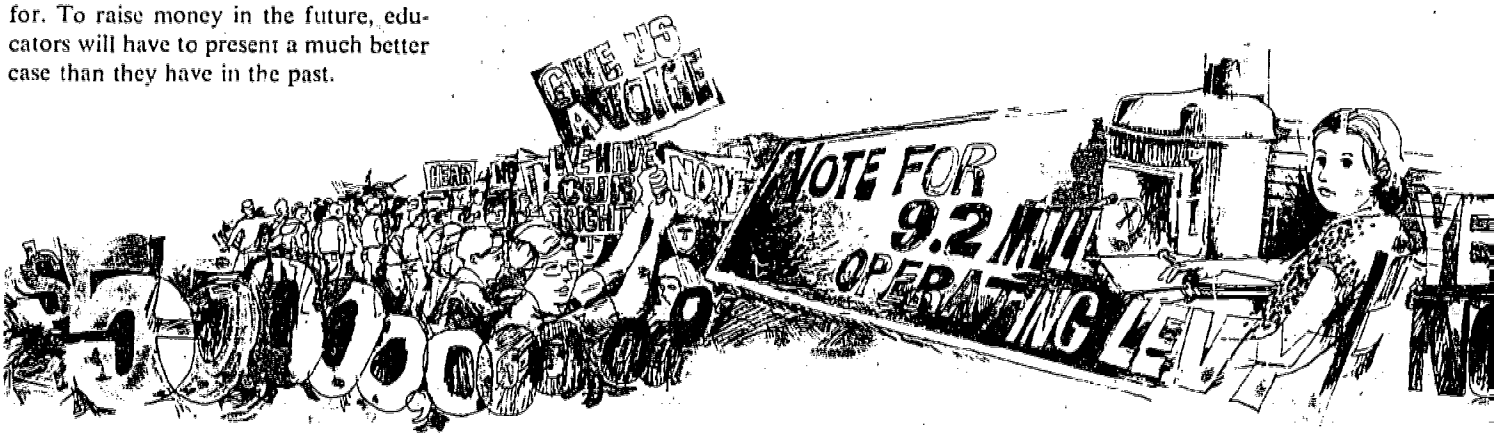
Much can be said in identifying and summarizing the expectations and forces impinging on education, and also the reactions of the system to the pressure. One of the more promising responses of the educational establishment has been to recognize the necessity for expanded R & D. Former U.S. Commissioner of Education, Dr. James E. Allen, sees the function of R & D as "providing active leadership in the setting of goals, in the identification of needs and priorities, and in the search for solutions for use at state and local levels." Federal support for research during the past 5 years has helped to stimulate the broadening interest and involvement of trained research people — through such legislation as the National Defense Education Act, the Cooperative Research Program, and the Vocational Education Act, which sets aside 10 percent of its appropriation for research.

Recent efforts have yielded four major developments that show considerable potential: (1) individualizing instruction, (2) exploiting educational technology, (3) making schools more accountable, and (4) systematizing the dissemination of information on improved practices and their use.

### *Individualizing Instruction*

Individually prescribed instruction (IPI) is designed to adapt education to the ability levels and learning styles of students who have varying backgrounds and aspirations. The basic, empirically proven premise that supports IPI is: students learn at different rates and in different ways. When a program of instruction is tailored to their interests, abilities, and styles of learning, 90 percent of our students can master most subjects. However, achieving optimal learning will require a raft of new teaching materials and methods, better administrative procedures, and modified organizational patterns as well as profound changes in the attitudes of teachers and administrators.

Many professionals who are researching curricula view today's stress upon IPI as progress beyond the discipline-centered reform movement that was started back in the early 1950's. They are interested in adapting improved course content to the requirements of individual students through a process of trial, evaluation, and modification.



Curriculum planners need: (1) educational objectives that are more precisely defined, (2) better ways of measuring student attainment of those objectives, and (3) methods of matching students and appropriate learning materials. By aligning what is to be learned with the information processing habits of students, we can offer alternative pathways for most students, not just the verbally gifted, to follow in order to achieve at least the minimum ability to function as adults. Reforming the curriculum subject by subject must continue. However, it is increasingly recognized that separate, unrelated courses will not necessarily lead to a balanced education or, for that matter, a minimally adequate one. Horizontal, as well as vertical, integration or synthesis of subject areas is required.

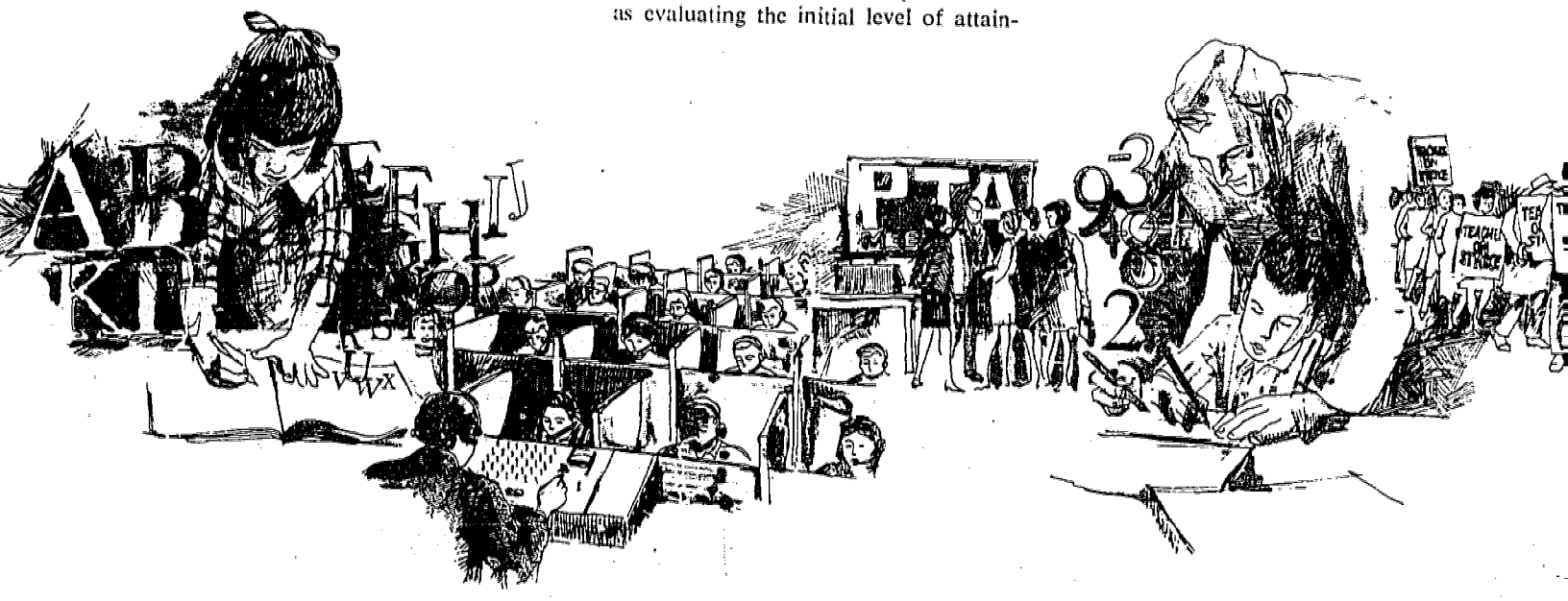
Learning readiness and academic achievement seem to depend as much on teaching method as on subject matter. This is almost a commonplace observation today. Even 2- and 3-year olds are being taught to read. Schools are beginning to react to advances in the theory of instruction by organizing nongraded and continuous-progress programs or by grouping students according to their interests, abilities, and styles of learning. Also, experiments are under way with team teaching and other ways of handling the various teaching functions that provide flexibility in the size of classes and better matching of teaching abilities to the instructional chores. Thus, there is a strong trend toward centering teaching on the learners rather than on the teachers.

Successful learning experiences that are tailored to the individual students are helping to neutralize the negative feelings of the more reluctant ones. As an example, the Minneapolis Public Schools offer potential dropouts individualized work/study opportunities as a way of completing high school. Further, the Hudson School at Hudson, Ohio, allows below-average students to study at their own pace and also urges them to assist their fellow students overcome particular hangups. Success in both locales has bolstered the sense of competence and the degree of control that these students feel in regard to their own destiny — an important outlook for the mature personality.

Probably the most dramatic example of the use of individualized instructional techniques is offered by the Research for Better Schools, Inc. (RBS) in Philadelphia. Some 190 elementary schools throughout the U.S. are working with RBS in individualizing their teaching programs over a 5-year period. RBS field-tests, monitors, and disseminates the IPI system that was developed originally by the Learning Research and Development Center at the University of Pittsburgh. In the IPI program the teacher is still at the heart of the system, but he takes on such new responsibilities as evaluating the initial level of attainment of the individual student in a given area, prescribing learning sequences, monitoring progress, testing, and repeating the cycle as the student progresses to the next higher level of learning.

One of the encouraging developments from the RBS program is the meticulous packaging of the total system, from statements of the learning objectives to teacher training materials. The IPI program is ready-made for installation and implementation.

A somewhat different approach to individualizing instruction, also pioneered by the University of Pittsburgh's Learning Research and Development Center, is being taken at the Henry Clay Frick Elementary School in Pittsburgh. Its promising Primary Education Project (PEP) involves about 375 children aged 3 to 6 years. Basically, PEP is designed to teach "intelligence." Following an IPI format, the project is trying to accomplish its mission by employing a carefully worked out, programmed sequence of learning materials; this is expected to develop those basic learning skills that will enable the youngsters to score better on intelligence tests. Each basic skill is broken down into an appropriate learning sequence or hierarchy of skills, which, in turn, is translated into a curriculum that will enable the student to acquire that skill.



### *Exploiting Educational Technology*

Another development, though not yet under full steam, has been given a lot of publicity and is being looked to by leading businessmen and educators as a means of improving the effectiveness of the learning process while helping to stretch the educational dollar. This is the exploitation of instructional technology. The recent report to the President by the Commission on Instructional Technology broadens the usual definition by characterizing instructional technology as "a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives . . . employing a combination of human and nonhuman resources to bring about more effective instruction." Harnessing the recent wave of innovations in the information processing field to the needs of education offers many potential advantages. Among them are the more productive use of a student's and teacher's time, greater flexibility and enrichment of learning materials, continuous monitoring and evaluation of the individual student's progress, and more effective ways of linking the school and real world environments to create more relevant learning experiences.

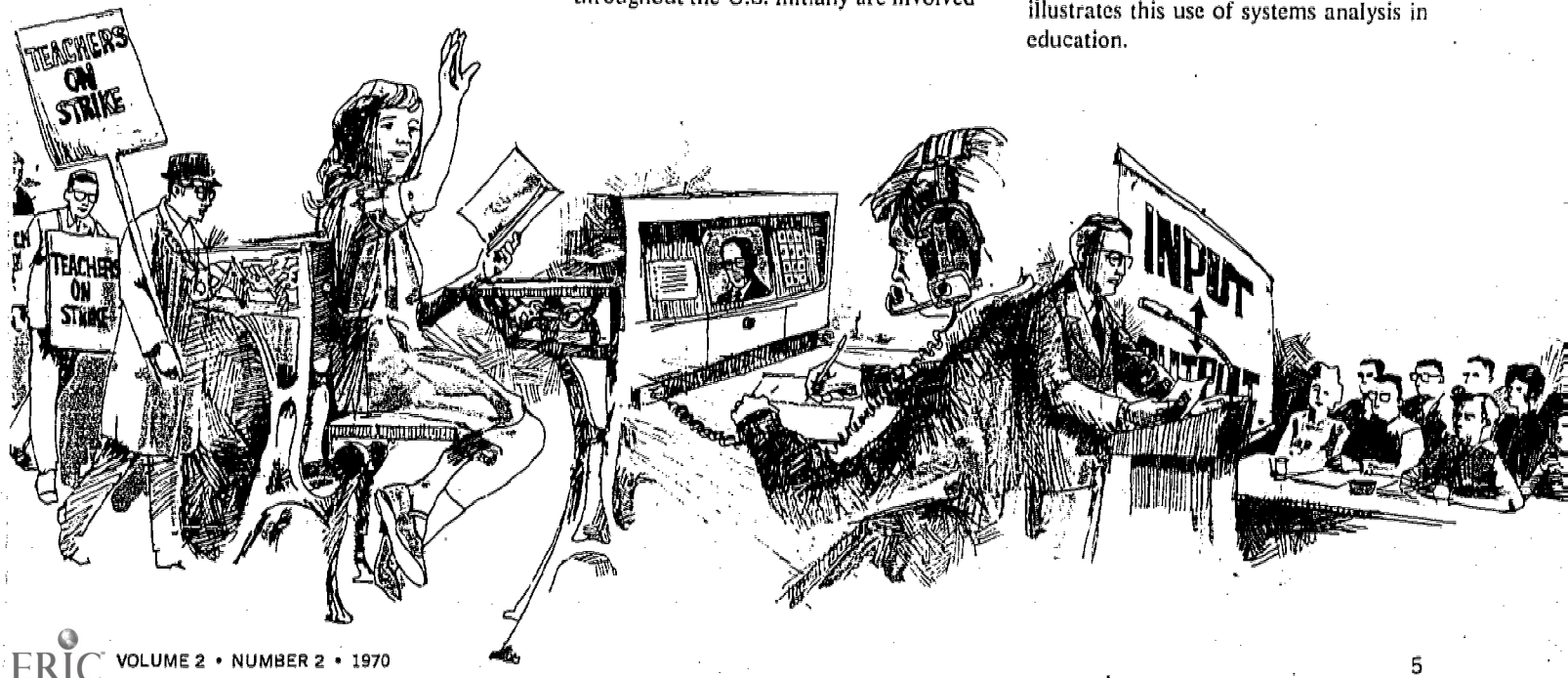
Such institutions as the Oakland Community College near Detroit and the Naval Academy at Annapolis have been demonstrating the feasibility of self-study, multi-media programs in institutional settings. The Annapolis project, financed jointly by the U.S. Office of Education and the Department of the Navy, has successfully field-tested a computer-managed instructional system in three major subjects that are covered during the first semester of the freshman year. The computer is being used to mediate between the student and an array of instructional resources that was put together to facilitate achieving specific performance objectives.

Computer-managed instruction, while in some minds synonomous with IPI, is emerging as an important means of furnishing support to the teacher. Project PLAN, a major undertaking by the Westinghouse Learning Corporation to overhaul Grades 1 through 12, exploits the computer as a teacher aid. It serves as an information system that records a student's learning and academic history and his program of studies, scores the tests, and furnishes the teacher up-to-date information on a student's status at a moment's notice. By monitoring a student's day-to-day progress, the teacher is alerted to that student's problems as they occur. Incidentally, Project PLAN represents one of the first really systematic attempts to cover all academic, vocational preparation, and guidance areas at the elementary and secondary levels. Fourteen school districts scattered throughout the U.S. initially are involved as testing and validation centers for this project.

A potentially important aspect of applying new technology has been the design and field testing of computer-based guidance systems. These provide both students and guidance counselors with detailed job information and skill requirements in a form that enables the students to estimate their own chances of success in given occupations based upon their backgrounds, previous school records, and aptitudes. At the same time, such systems permit the guidance counselors to prescribe for the students and to advise them on appropriate career strategies.

### *Making Schools More Accountable*

A third development, the use of systems analysis, may well revolutionize school planning programs and financial accounting procedures. This is an outgrowth of industry's and the military's experience with a more systematic approach to the allocation of resources and the assessment of the benefits derived from such allocation. By bringing systems analysis into the management of educational systems, many hope to ensure that reform efforts in education will shift from abstract theorizing about needs and practices to a more hard-nosed, empirical approach. One of the following articles, on the Planning-Programming-Budgeting System (PPBS), illustrates this use of systems analysis in education.



### *Spreading the Word Systematically*

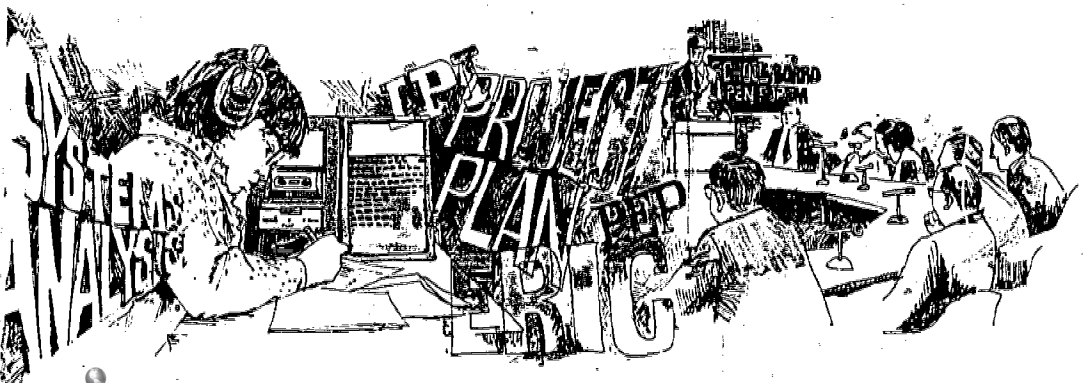
Finally, the evolution of "educational engineering services" offers perhaps the greatest potential for improving education in the long run. This movement models itself after the Agricultural Extension Service, which has done so much to up the productivity of farms in the U.S. during the last 100 years. Current interest in such educational services builds upon two decades of systematic research on bringing scientific knowledge to the practitioner in understandable form. Information systems such as the 20 Educational Research Information Centers (ERIC) — located primarily at universities scattered throughout the country — acquire, screen, store, and electronically disseminate reams of distilled information to those who need it. Skills in identifying the problem and providing consulting help in solving it are being taught to a cadre of "linking agents" whose primary mission will be to tie user groups, e.g., schools, to a cornucopia of field-tested educational resources available at these centers. Further, to provide these services, this new breed of "educational engineers" must be trained to apply the results of research with particular sensitivity to the practical constraints and immediate pressures under which the school administrator and his staff operate.

Several other educational information services are now in the demonstration or operational stage. In addition to the ERIC clearinghouses, there are 50 state Research Coordinating Units (designed to assist in the dissemination of improved vocational education practices), 15 regional Educational Research Laboratories, and innumerable county or regional development centers within states, such as New York State's Board of Cooperative Educational Services.

## OPENING DOORS TO THE FUTURE

If these developments are to resolve the conditions that have led to the rising clamor for more democratic, relevant, and humanistic educational programs, and if we are to design schools that are responsive to changing demands and yet are economical in their use of resources, the key is to become more "results-oriented" in evolving ways to improve the educational process. The last 20 years have been dominated by the almost "theological" assumption that schools are, in fact, providing something of value. During that period, educational objectives have been couched in vague and ambiguous terms, instead of in terms of the impact of the learning experiences on the student. Objectives laid out on this latter basis would not limit the would-be innovator to the reshuffling of outmoded procedures.

Relating objectives in terms of "output" — improvement in student performance — opens up the possibility of incorporating in the system a vast new array of learning opportunities that may be developed both inside and outside the present educational establishment. Significant and dramatic improvements can be realized by taking this new perspective, that is, by focusing on improving the performance of the student, with a careful appraisal of what works and what doesn't. Even if it is not the only criterion for judging an educational system, improved student performance is certainly one of the most significant.




**David S. Bushnell,** a Battelle Institute Fellow for the past year, is director of research for the long-range planning study of U.S. community colleges that is sponsored by the Kellogg Foundation, and also is a Battelle-Columbus consultant. As a fellow, Dave worked on two books; *Planned Change in Education: A Systems Analytic Approach* will be published by Harcourt, Brace and World in the spring of 1971, and *An Educational System for the Seventies: A Case Study* will appear later. Before coming to Battelle, he was director of comprehensive and vocational research in the U.S. Office of Education, and previously had done research in the behavioral sciences at Stanford Research Institute. A consultant to various state departments of education and local school districts, Dave serves on the editorial board of the *Journal of Human Resources* (University of Wisconsin) and on the board of advisory editors for *Trans-Action* (Rutgers University).

# Center for Improved Education

On August 1, Battelle launched the Center for Improved Education. A staff of specialists in education, behavioral sciences, systems analysis, and other fields is already conducting studies in line with the Center's objectives, which are to:

- Perform creative educational research
- Develop new educational technology and programs
- Collect, analyze, and disseminate data and information for educational planners and decision-makers
- Provide training in new concepts and methods for teachers, school administrators, school board members, and educational planners
- Furnish technical advisory services to educators involved in educational change.

School systems are caught up in numerous problems—lack of precise goals and objectives, the need for program and system evaluation, inadequate training of staff, student unrest, teacher militancy, racial strife, and taxpayer resistance. Progressive educators, in trying to cope with these problems, look to improved technology and scientific management methods to achieve solutions.

The basic philosophy underlying the establishment of the Center is that science and technology have much to offer in solving these problems, that technological contributions must be molded to the human dimension, and that humanness must serve as master and technology as servant.

The Center is a technical resource for educators around the country. The ultimate goal is to help bring about educational change for the benefit of the student and the community.

**William D. Hitt**
Director
Center for Improved Education

# Bringing Management by

*by William D. Hitt*

WE HEAR A GREAT DEAL today about "management by objectives", especially in business and industry. Success in directing a commercial enterprise usually is based on skillfully designing useful objectives that mark progress toward the fulfillment of worthwhile goals, and on developing and carrying out procedures for attaining those objectives, and thus the goals. Can a management approach that is so successful in business and industry help education as well? Let's take a look.

Like businesses, school systems need clearly defined statements of what they want to accomplish. Basically, such statements are of two types: *goals*, which are long-term and may be philosophical, idealistic, and even visionary, and *objectives*, which are short-term and attainable, and function as steps to the goals.

A goal of the U.S., according to the Declaration of Independence, is to guard the inalienable rights of the individual to ". . . Life, Liberty, and the pursuit of Happiness." Some years ago AT&T's board chairman cited as a company goal "good, cheap, fast worldwide service for everyone." For school systems a typical goal would be "to develop in each student the ability to acquire and use knowledge effectively."

Objectives, on the other hand, are likely to be more sharply focused and down-to-earth. School systems might work toward objectives such as improving the reading achievement of disadvantaged students by a specific amount or decreasing the student dropout rate by a certain percentage. Objectives, unlike goals, can be measured quantitatively and thus can serve as milestones of progress.

Our concern here centers on using proper goals and objectives in managing educational systems—nominally, management by objectives. This is not a simple matter. School systems involve many types of activities. Consider the kaleidoscope of responsibilities facing the school superintendent. He must deal with the curriculum, the staff that administers and teaches it, the facilities and buildings that house and serve the schools, the long- and short-range financing, and not the least, the relations of the school system to the parents and taxpayers. Somehow, the superintendent must pull all these elements together — coordinate, organize, and direct them — so that the system will move toward its goals.

## GOALS AND EDUCATION TODAY

No organization, much less an educational system, can operate meaningfully unless all of its components are working toward common goals. These goals must be stated lucidly and publicized widely so that all concerned will understand and hopefully will accept them; they must come through loud and crystal-clear. The goals for school systems should be tailored specifically, because each system is unique and must set its own direction. And when the time for evaluation comes, there is only one way to determine how the school system is doing, and that is by measuring its progress against its own goals.

Goals should be challenging. They should not be so idealistic and so far out that they are completely unrealistic; nor should they be so pedestrian that little or no real effort is needed to attain them. The ideal goal for a school system is one that is just beyond its grasp.

Consider a school system recently studied by Battelle-Columbus staff members. The school board had said: "Evaluate the program, facilities, and personnel of our system." The research team began its study by asking: "What are your goals — what are you trying to accomplish?" The answer was an embarrassed silence.

This made life difficult for the research team. They had no definite basis for evaluating the effectiveness of the system under study. In the absence of stated goals, the question arose: Should this school system be compared with some ideal system or some general set of guidelines not specifically tied to the school system itself?

Some bases for evaluation finally were set up. Two were chosen to give ballpark indications: how that system met the state's minimum requirements, and how it compared with the study team's conception of a high-quality educational organization. Neither criterion permitted a meaningful evaluation.

Such lack of goals also comes back to haunt school systems when they go to taxpayers for more funds. What answers can be given when the voters ask, "What are you trying to achieve? Can you give us a good reason for requesting more of our money?" The skepticism underlying such questioning has now become an important factor in voting, as schoolmen know. During a 4-month period in Ohio last year, out of 201 school tax levies and bond issues voted on, 108 were turned down. Many of these lost out because the voters either disagreed with the school system's goals or didn't understand what they were. How can taxpayers know where the schools are trying to go or how well they are getting there unless proper goals are defined and communicated?

### *Setting Goals*

Who should formulate the goals? Even when the system recognizes the importance of goals, the efforts to establish

# Objectives to Schools

them and subsequently to implement them often are handled ineffectively. In some systems, goals are handed down from on high — by the superintendent's office, the school board, or a specially appointed committee. When this happens, those who must work to attain them, as teachers, or those who are affected by them, as students and parents, are likely to be unhappy and might even refuse to accept them.

Yet, when the task of setting a school system's goals is placed in the hands of those who must live with them, confusion can result. Recently, PTA members and teachers of an elementary school met to lay out broad goals for the school in order to provide guidelines for developing the curriculum and for communicating with parents. As the effort began, teachers said, in effect, "Tell us what you want, and we'll try to carry it out." Parents replied, "You're the educators. Tell us what is best for our children."

Because schools exist basically to teach the young and to prepare them for life in the world, the entire community has a real stake in the school system. Therefore, all those who have children to be educated, who must finance the schools, and who genuinely care about the future of their community should have a voice in determining the direction of the schools. Their right, and responsibility, to participate in formulating goals must be recognized. This, in turn, calls for creating the means for getting all of these groups to contribute to the development of worthwhile goals and for clearly communicating what role each might be expected to play. The wise school administrator will take the steps needed to handle this task successfully.

### *Emphasizing the Important Goals*

Establishing priorities for various goals and selecting appropriate means for accomplishing the objectives are critical to the effectiveness of the school system. For example, if goals relating to buildings, equipment, and facilities dominate a school system's operation, then that system is being led down a primrose path; when concern for the student and his involvement in learning gets pushed aside, the net accomplishments of the system will be questionable. If covering the work plan for that day's class session precludes the student from participating in life situations where true learning can occur or if there is no leeway for exploiting an unexpected learning experience, then something is wrong with the way the goals are being pursued.

It is essential to give precedence to the most important goals. A school system may be committed to helping each student achieve a successful life and also to creating the best possible school plant. When the superintendent is organizing his plans for attacking these two goals, he may give more attention to the latter, because it is easier to pin down. Thus, the more important goals often must play second fiddle, because they generally are more elusive.

The situation is indeed sorriest where excellent goals have been set up, but are disregarded in actual operations. At the beginning of a study to design a model prison education and training program, the Battelle-Columbus research team was informed with great emphasis that the primary goal of the prison system is to help inmates become productive members of society. When asked "On what basis is your performance evaluated?", the warden listed these: (1) the number and severity of disturbances, (2) his ability to stay within the budget, and (3) the profit generated by the prison industries. Real-life circumstances denied the true importance of the stated goal for the prison system. Obviously, preoccupation with goals that should be low in priority, or should not exist at all, will dilute or even negate efforts to achieve what should be the prime goals.

## OBJECTIVES AS STEPS TO GOALS

Reaching a goal is usually a long-term process that involves several intermediate steps. To insure that these steps go in the right direction, each must be carefully defined and oriented. If we take objectives to be synonymous with these steps, then this process calls for setting up and implementing a limited number of achievable objectives. These may be designed to cover the school system as a whole, one educational program (e.g., vocational education), or one course (e.g., auto mechanics). If the system's goals are to be achieved, the objectives for any part of the system must be consistent with those goals.

Objectives should meet three standards. They should: (1) clearly state the type of behavior that is desired; (2) specify the criteria of acceptable performance; and (3) state the conditions. Let us take, for example, an objective that relates to increasing the reading ability of disadvantaged youngsters. If it specifies that after 16 hours of instruction, 90 percent of all students should have 75 percent accuracy on a standardized reading test, achievement can be measured effectively. If any one element were omitted, say, the term of instruction or the kind of test to be used, then the objective would be too vague, and the extent to which it was attained could not be evaluated.

Flexibility is essential in the establishment of an objectives-based curriculum. For example, we cannot expect

the same type of performance from every student. Therefore, objectives should recognize variances in abilities and allow each person to be evaluated on the basis of his abilities. In the classroom situation, moreover, the teacher's daily lesson plan should not be so inflexible that it is limited to prescribed materials, which, of necessity, disregard what is happening in the world at that moment. Many of these happenings, like the moonshot, have direct relevance to the student's life and learning situation, and must be dealt with. Objectives, therefore, must give the teacher latitude to take advantage of the unanticipated.

When objectives are being set, resources and constraints also must be considered. What funds are available to finance desirable activities? Can the students afford to pay something toward worthwhile activities — for materials, trips, or extra equipment? Which local people might volunteer to assist in enriching the educational program? What public facilities — museums, arboretums, etc. — are accessible? In another direction, those establishing objectives must consider legal requirements and the community's social, economic, and political conditions.

## MANAGING SCHOOL SYSTEMS

Reaping the real advantages of managing by objectives requires careful consideration of the organizational structure that will be used in applying it. Agreeing on goals and objectives demands the cooperation of many groups. The ability to accomplish the established objectives depends upon having people who are dependable, capable, and willing to work on the task. As is typical of all management methods, managing by objectives is successful only when coordination is maintained with many people and cooperation is obtained from them, when responsibilities can be assigned with the assurance that they will be assumed, and when there is genuine commitment to the desirability of pursuing the objectives using all available resources and talents.

Generally, four basic types of organization are seen in school systems:

1. *Authoritarian.* With this type, information and direction flow from the top down. The boss gives the orders and calls out the goals and objectives. Subordinates are expected to carry them out. The teaching staff, students, and people in the community have little or no voice in shaping the system. Therefore, they are likely to have little interest in achieving the goals and objectives that are specified for them.
2. *Laissez-faire.* Here, each staff member pretty much goes his own way. If objectives are formalized, they are likely to have little relation to the system's goals — if these are even stated. And since communications are likely to be sporadic or non-existent, little or no attempt is made to reach agreement on ultimate purposes or on any other facet of the system.
3. *Management-labor.* Under such management, school matters are likely to be polarized between the administrators and the teachers. As a result, there will be differences in goals and conflicts in objectives, and the school system will be pulled in different directions.

4. *Participative.* This type of management is based upon cooperation by all concerned groups—supervisors, teaching staff, students, and parents. Goals and objectives are established in concert, and all parties work together to attain them. All these people participate actively in the communication process, which operates both up and down and outside the school system. Within the framework of participative management, a formal structure of responsibilities is agreed upon and accepted; those who make the final decisions are also accountable for the results.

The participative type of organization is best fitted to managing by objectives. It incorporates what the philosopher Hegel pointed out years ago, "If I am to exert myself for any object, it must, in some way, be my object." The message for the educational manager is this: get your people immersed in formulating and working toward achieving goals and objectives. The school system and everyone associated with it will benefit. When teachers, parents, and students as well as the superintendent, other administrators, and the school board

join forces in designing the basic framework, the school system becomes an authentic *community* educational system; it is a true extension of the participants.

## ORGANIZING THE SCHOOL SYSTEM

The superintendent or manager of a school system will find that managing by objectives will be a refreshing experience, but not an easy one. He will be able to develop schools that meet the needs of the community and that, in turn, elicit a response from the community. At the same time, he will have evolved a system that will adjust continually to changes in the community and that will reach out to sense and to employ measures that will keep the schools alive and forward-looking.

In general terms, these are the steps that management by objectives calls for:

First, the community's needs and desires should be assessed. This requires inputs from all elements of the community. To provide proper balance, information also should be obtained from the students — directly. Assessment of these inputs will lead to an educational program that will fit the community and the student. This process should be repeated periodically. These inputs will point the way to the instructional, social, ethical, and economic goals that should be established.

With the goals formulated, the next step is to specify the objectives that, when attained, will most effectively accomplish the desired ends. Following this, the type of staff members needed to achieve the objectives, and also the matter of supplementary training for those people, should be considered.

The budgeting of funds is, of course, another major consideration. Each part of the overall program should be reviewed to decide how much financial support it should receive. The balancing of priorities among the various goals and objectives is a critical step in the total process.

Finally, the program should be evaluated in regard to the cost-effectiveness of its various elements. In terms of the stated objectives, these kinds of questions should be asked: What has been accomplished? How much did it cost to achieve that much? What should be done to help the system better achieve its objectives? Answers that are based on both cost and effectiveness must be sought.

## THE ADVANTAGES

Managing by objectives entails an effort that cannot merely be added to the regular, everyday activities of a school administrator, because it represents an approach that is basically different from other approaches to school management. Although managing by objectives will require time for implementation, it should reduce the time that the administrator has to spend in putting out fires.

Properly administered, this management approach will provide several benefits to a school system:

1. Orderly growth of each school's educational program, together with the facilities for implementing it
2. Better recognition and understanding of alternative courses of action
3. A systematic and rational basis for evaluating the program
4. Sensitive means for alerting administrators to drift in the system or its parts
5. An effective mechanism for communicating job responsibilities to all staff members in the system
6. A sound basis for further development of the staff
7. A solid foundation for bringing about cooperation among all those concerned with the educational system.

The net result will be a school system that is geared to the community's needs and desires, to the student's hopes and ambitions, and to the world's trials.

# THE CURRICULUM: MAKE IT RELEVANT! MAKE IT WORK!

*by Ronald J. Cress and Robert F. Rubeck*

**"Why do I have to take physics? I'm going to be a social worker!"**

**"I think it's unfair! Just because I'm going on to college, I've got to sit through this boring class!"**

**"This course wouldn't be too bad if I'd learned anything last semester."**

**"The school wants another raise in taxes. Giving it more money doesn't seem to be buying better education for our kids."**

THERE IS A PINCER squeezing the educator. One jaw is the taxpayer, who is pressing school systems to prove that they really are effectively and efficiently educating the children entrusted to them. The other is the student, who is loudly demanding courses that are relevant to both his immediate and future needs.

Satisfying both demands requires curricula that are sound psychologically and educationally. The major factor in the recent development of such curricula has been the formalizing of precise objectives to be achieved through instruction. This practice gained considerable favor as a result of programmed instruction; it plays a vital role in applying the Planning-Programming-Budgeting System (PPBS—discussed here in a later article); and it is beginning to exert the influence it warrants on education in general and on curriculum design in particular. Although setting up objectives for certain courses of study is hard work, it now seems reasonable to assume that they can be specified for all areas of education.

## OBJECTIVES IN THE DESIGN OF CURRICULA

As the use of goals and objectives in education gains momentum around the country, it becomes increasingly difficult to see how school systems are going to evolve meaningful, timely curricula for today's student without them. When considering the design of a course, educators must turn away from such questions as: "How can we develop a more effective geometry program?" Instead, they must phrase them in terms of relevancy to the student: "What, if anything, is important for most students to be able to do as a result of a course in geometry?" The process of finding the answer is largely one of developing relevant course objectives.

Designing such objectives and also effective means of achieving them is a complicated, but critical and rewarding task. The following indicates just what is required.

### *Real-World Inputs*

A good place to start designing a curriculum is to determine what elements of the adult world should be included in the child's learning. A practical way to decide is to survey the community and generate a detailed description of its desired educational end-product—the graduating student. Parents, nonparents, students, employers, educators, and others should have a part in defining the skills and behaviors that are fundamental to a successful adult life. In establishing this profile, it may be necessary to consider skills and subject matter that are not typically provided by our schools—especially those of particular interest to the community. For example, the ability to listen, as well as to speak, may be viewed as important in the community and, therefore, should be included in the educational profile.

Other inputs from the outside world are also significant. Manpower forecasts should be factored in so that students can be trained for jobs that will be available when they graduate. The curriculum planners also must provide for any limitations imposed by state law, Federal regulations, finances, and other possible external conditions.

With such real-world inputs in hand, the planners can turn to instructional and student needs.

### *Instructional and Student Needs*

Instructional needs refer to the kind of course content that is desired or demanded. This is determined by closely examining a course's educational history, its present content, and the performance of students who have taken it. If the investigation shows that instruction has not been adequate, specific alterations should be called for. Other factors may also make changes necessary: the expectation of greater learning by the students in certain subjects, the need to add new material, or a change in the way the content applies in society.

The needs of the students are reflected in the desires, interests, and aspirations that they express or otherwise reveal. The courses and outside activities that

students choose also provide major clues. Further, such student characteristics as IQ, reading level, and socioeconomic background give relevant information. These characteristics can be confirmed and detailed through individual and small group conferences.

### *Instructional Goals and Objectives*

With curricular needs established, the planners are ready to state explicit instructional goals — the ends toward which instruction will strive. In this sense, the goals provide direction to the steps to be taken in designing and implementing instruction. Thus, instructional goals furnish a rationale and give the intentions of instruction. The steps toward attaining these goals are embodied in more strictly defined instructional objectives that call out specific tasks, how they are to be accomplished, and how those accomplishments are to be measured. Instructional goals and objectives must be set up for individual courses, for major programs of course study, and for the curriculum as a whole.

The difference between an instructional goal and one related instructional objective is shown by the following:

*Instructional goal:* During the primary years, students will acquire a firm understanding of basic addition and subtraction concepts.

*One instructional objective:* By the age of nine, 90 percent of the students will be able to subtract any number from any larger number with at least 90 percent accuracy.

In summary, inputs from the real world affect the instructional and student needs. The determination of these needs aids in specifying the instructional goals. Then these goals, together with the characteristics of the students, provide a basis for selecting or formulating sound instructional objectives.

## PREPARING AND IMPLEMENTING OBJECTIVES

Having accounted for the inputs needed, let us turn to the problems of preparing instructional objectives. The objectives for a given course, for example, may be written by one teacher who is appropriate for the task, by the staff of the department concerned, or by a larger group that may include administrators or other teachers. In such cases, the objectives reflect views that are typical of the school system. The basic viewpoints can be broadened by using teacher-teams from different schools or school systems; employing a broadened base of knowledge and experience is certainly desirable.

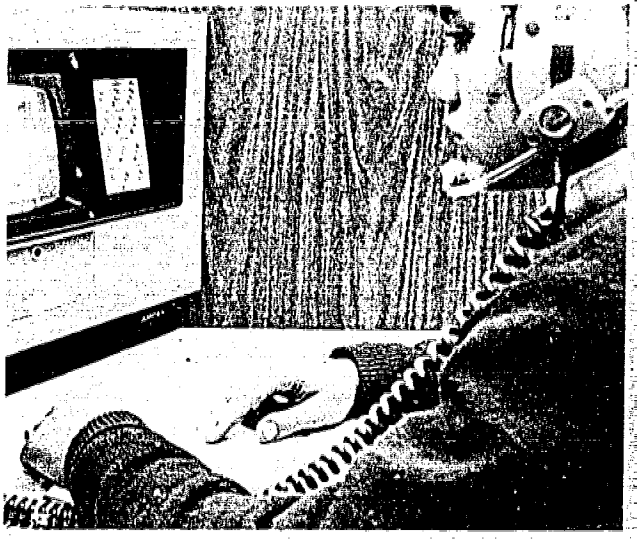
Probably the soundest curricular objectives will result from taking well-prepared objectives from outside the district as a base and adapting them to meet local requirements. Well-stated objectives are likely to be available for any widely presented course. One rich source of objectives is the Objective Exchange at the University of California at Los Angeles. It holds large numbers of objectives and corresponding testing items for all areas of primary- and secondary-school curricula, and provides these at a relatively low cost.

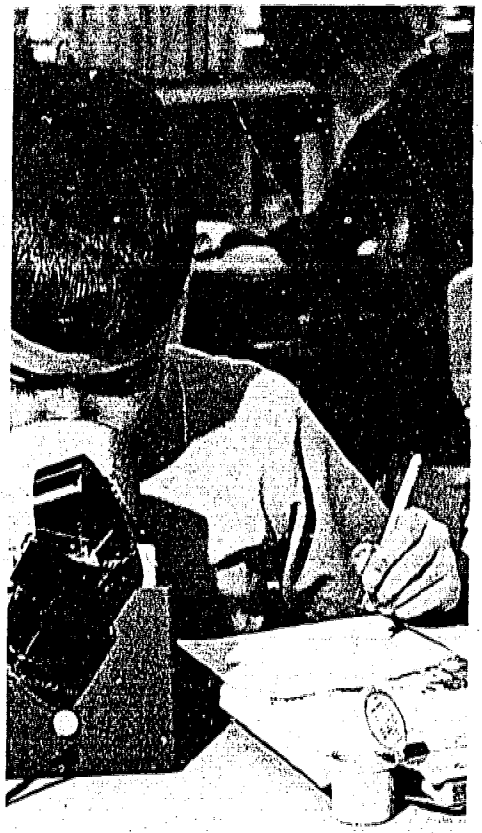
Once the instructional objectives have been established, they must be supplemented with detailed directions for applying the five major elements of instruction: learning activities, resources, instructional mode or methodology, learning environment, and evaluation.

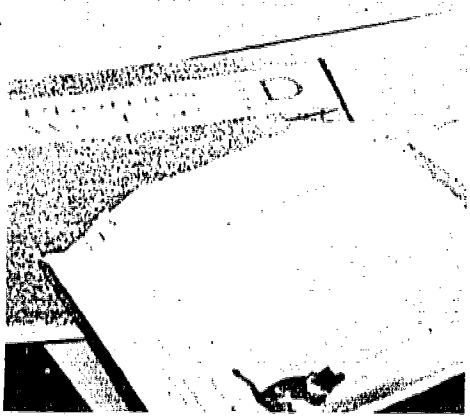
*Learning activities* are basically whatever the student does, under the aegis of the school, to gain new knowledge and acquire desired behaviors, and to develop skill in using them. Independent study, group discussion, research projects, and planned trips are examples of learning activities. Sometimes instructional objectives can be attained with the learning activities already in use; more often, the establishment of objectives will indicate needed modifications.

*Resources* are the materials, persons, and facilities that enhance what the learner derives from his school-sponsored activities. These must be identified and used. Learning resources include printed materials, knowledgeable people, films, recordings, and the various devices provided by the current educational technology that can help the student learn what the objectives require.

*Instructional mode or methodology* of learning relates to the way the activities and resources are organized. The learning mode may involve as little







as the sequence of classroom and workbook activities, or as much as the pattern of conditions and the sequence of events in a multimedia self-instruction program that includes programmed instructional material, group discussions, and materials and devices for individual use.

*Learning environment* refers to the setting. This always should be as conducive as possible to learning within the conditions of the instructional objectives. A classroom, library, laboratory, study carrel, or home environment may be appropriate.

*Evaluation* involves the means of assessing student performance in line with the instructional objectives. Well-designed tests produce two very important results: they tell about the student's progress in meeting the objectives, and they yield data for upgrading instruction.

At this stage, the planned curriculum or, more likely, the organized course is ready to be presented to the students. When it is first offered, those who are teaching it should keep a sharp eye out to learn how successfully the objectives are achieved. Feedback from tests will be more important for what it reveals about the instruction than for what it discloses about the student. For instance, in group instruction, if the test results show that a large percentage of students are not attaining a given objective, then that would be the signal for reviewing the objective and/or the instructional steps used, and making adjustments. Such looping back — evaluating and revising on the basis of student achievement — is essential to developing and maintaining a curriculum that is both relevant and effective for students.

## APPROACHES TO IMPROVED CURRICULA

The advantages of building curricula upon goals and objectives are being demonstrated today in a number of school systems. In some cases, specialists designed these curricula in generalized forms that could be adapted readily to various school systems. In other instances, skilled consultants helped develop the curricula for specific school systems. Another way to get such curricula is to train curriculum planners within a school system so that they can do the job for their local situation.

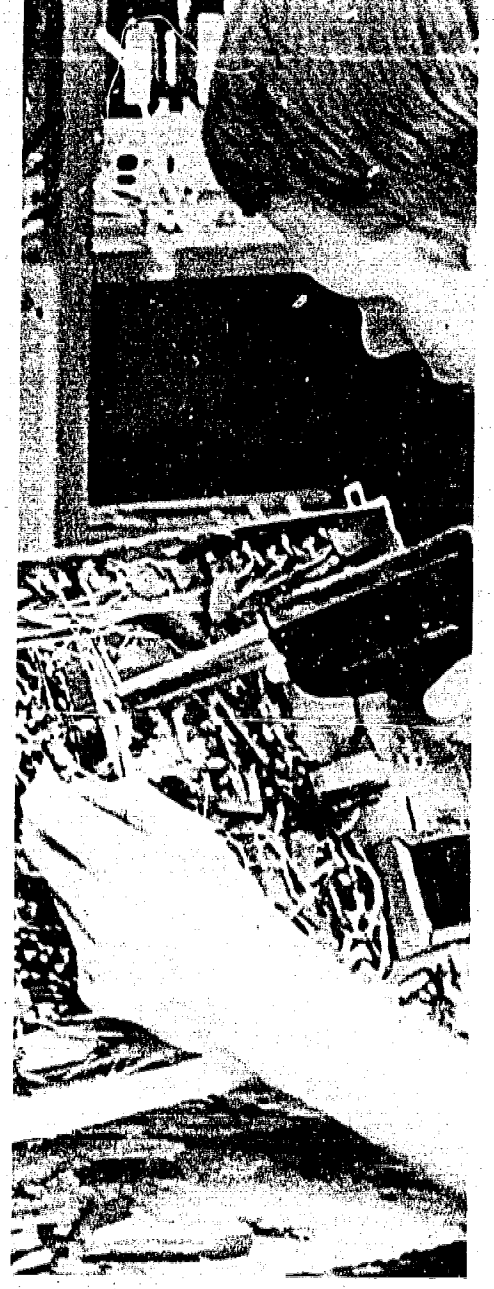
Basing curricula on goals and objectives opens various approaches to student/school relationships. The following examples describe the use of goals and objectives in establishing individualized instruction and in creating or modifying curricula for more conventionally organized schools.

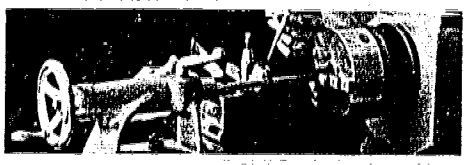
### *Individualized Instruction*

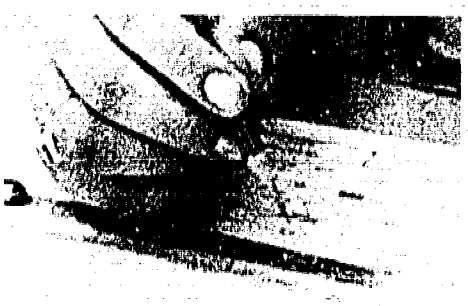
With the growing awareness of how students vary in their learning ability, individualized instruction is becoming more and more desirable. As far back as 1954, the Learning Research and Development Center at the University of Pittsburgh was setting the stage for what is now known as Individually Prescribed Instruction (IPI). Research in programmed instruction and in learning rate, pacing, and individual differences of students marked the historical beginnings of IPI. By the mid-1960's, however, the effort had blossomed into a more comprehensive study of how to design curricula for individualized instruction.

At present, the process for developing the IPI curriculum has much in common with the curricular design strategy discussed above. The IPI curriculum, for instance, also leans heavily on instructional objectives; real-world inputs for the original design and for subsequent revision are supplied by subject-matter experts and commercial producers of instructional materials. The IPI system is extremely sensitive to both instructional and student needs. Both are assessed through tests or conferences on nearly a daily basis to assure that instruction is tailored to the individual student. Diagnostic tests disclose his needs as he enters a course of study, and his progress in the course is monitored constantly. Unaccomplished objectives become the focus for further instruction.

The instructional needs of an IPI course are built into the scope and sequence of the instructional objectives. Placement tests determine what instruction a student or a group of students need. The objectives in the IPI program







guide the selection of instructional materials and the construction of both placement and diagnostic tests.

Originally, IPI courses depended heavily upon the available texts, workbooks, and other materials. Since then, materials tailored specifically to IPI have been developed, many of which are obtainable commercially.

In this individualized environment, various methods or modes of learning are used, each selected with full awareness and consideration of the objectives to be accomplished. This procedure leads to a varied and stimulating learning environment where motivation is typically high.

The instructional-objectives foundation of the IPI curriculum facilitates evaluation of the student's performance. Each student's final or interim achievement is assessed by how he measures up to the specifications called out in the objectives.

An interesting use of individualized instruction is being put to work in the Nova school system in Broward County, Florida. Nova employs many of the curriculum design principles discussed previously, but approaches them somewhat differently. Its overriding goal is to provide county residents with a high-quality education from kindergarten through Ph.D. on one campus.

Three rules guide Nova's curriculum development: (1) the instructional system makes sure that the learner knows what he is to learn, (2) it keeps a watchful eye on his progress and guides him when he needs help, and (3) it furnishes him many learning materials and suggested learning methods.

Nova works toward its long-range goal by applying its curriculum development rules through "Learning Activity Packages" (LAP's). These are instructional packages that are based on agreed upon objectives, designed to guide individual learning. New LAP's are written usually as a result of real-world inputs in the form of a timely social consideration, a new vocational specialty, or the growth of a new field of interest (for example, pollution). Each LAP specifies the instructional needs it serves. It accomplishes this by explaining to the student (1) the background of the content covered, (2) the reason for selecting the content, and (3) its possible future application. In this way, the LAP rationale tries to build relevancy into learning by uniting instructional need wth student need. After the student is indoctrinated in the background and rationale, Nova assesses his initial abilities in the content. This measurement gives the student an index of his particular strengths and needs. Each LAP also specifies objectives, to let the student know clearly what is expected of him.

A typical LAP lists resources together with keyed learning activities that provide the basic framework for the learning that is to be done, by a variety of methods in various settings. The student is free to choose his own package, place, and time for study. In this way, he can make his curriculum individually relevant.

Check points throughout the LAP let the student monitor his own progress. A final check is made by means of the LAP test. Thus, a valid assessment of attainment is provided for the student and for the Nova testing center, and, having successfully completed one LAP, the student moves on to another. As a result of the LAP, the Nova curriculum is interesting, individual, effective, efficient, and relevant.

### *Improving Existing Curricula*

Few school systems are ready to throw over their established curricula in favor of entirely new ones. Nevertheless, there is a widespread movement to adopt approaches that will enable schools to improve the content of their courses — to meet the rising demands upon graduates and to respond to the interests of students. At the same time, attention is focused on introducing educational methods that will lead to more effective learning.

Where funds can be made available, of course, schools can call in specialists to study the community's needs, characteristics, and desires; the students' interests and capabilities; and the available resources. These specially trained people can recast the curriculum on the basis of goals and objectives, and then install the resulting curriculum in the schools.

Another more gradual and less costly procedure can be followed; it involves training the school's own personnel to carry out the task. Once the schools have the know-how and the supportive organization to build curricula

upon goals and objectives, they can perform the various steps for starting or revising any desired course — from analyzing community characteristics and desires, through setting up objectives, to recasting the course, including the looping back and reevaluation that are so essential to keeping curricula up with the times.

The steps for modernizing curricula are well illustrated in a study that Battelle-Columbus is conducting for some 90 Ohio school districts. In Ohio, as elsewhere, the use of instructional goals and objectives in formulating curricula began to get attention fairly recently. Not many people are experienced in this method of building curricula. The project started, therefore, with a series of workshops for curriculum planners from various schools. Battelle specialists guided the attendees though a thorough grounding in the philosophy and methods of education by instructional goals and objectives, and through various tasks in developing curricula on that basis.

Part of the study also called for preparing, for all participating schools, a step-by-step manual for creating curricula using goals and objectives. The resulting manual sets forth a readily workable procedure for teachers who might be assigned to this task in their own schools. As such tasks are undertaken, the process may be overseen by Battelle curriculum planners, who also may be called upon to evaluate the finished products. By this procedure, knowledgeable groups are being created to carry on in each school system.

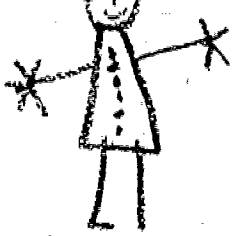
In another program that was performed for the school systems of Pike, Lawrence, and Scioto Counties in Ohio, the goal was to revise science studies for Kindergarten through Grade 8. Battelle-Columbus curriculum planners trained the 30 members of the group to prepare a goal- and objective-oriented curriculum, and guided the group in its survey of various existing curricula as a basis for the planned revision. With this guidance and with an evaluation of the final results, the group produced what appears to be a practicable and stimulating curriculum. It will have its pilot run this fall.

A related study of interest in the field of vocational training has been carried out in the State of Michigan. Since too often schools are turning out graduates without enough training for the jobs available, Battelle-Columbus conducted a program with two goals: (1) to reduce the discrepancies between the skills required by employers and those produced by existing curricula, and (2) to develop a methodology for enabling schools to keep such discrepancies small.

Ten occupations were picked for investigation in three communities: Detroit, representative of a large city; Grand Rapids, of a medium-sized city; and Mt. Pleasant, of a small community. The occupations — construction carpenter and construction electrician are two examples — were chosen because of their relation to Michigan's economic growth and because appropriate training can be provided by vocational educational institutions.

The study began by obtaining information, from selected companies of various types and sizes, about the knowledge and skills required from persons entering the various jobs. When all information was in hand, the job requirements were compared with the skills and knowledge provided by existing curricula. Discrepancies were identified; and then Battelle curriculum planners formulated recommendations for changes in curricula that would enable students to acquire the skills and knowledge they need in order to obtain and handle such jobs successfully.

In summary, the use of instructional goals and objectives as a basis for better curricula unquestionably would help satisfy the two critical demands on educational systems, namely, that they operate with much higher efficiency and effectiveness, and that they offer programs that relate directly to student's immediate and future needs. Instruction can be made more relevant to the student by gearing his learning steps to an empirically determined set of critical skills and knowledge, and by giving him continuing opportunities to select his own instructional objectives, learning activities, and resources. Effective curricula, on the other hand, can be obtained readily by employing challenging goals with precise objectives, backed up by continuous and rigorous evaluation of the course of study. Although the design and development of proper curricula constitute an arduous task, we believe that the benefits to be derived justify the effort expended.



# APPRAISING TEACHER PERFORMANCE

*by Dennis N. McFadden and E. Allen Schenck*

IT ALL HINGES on the teacher. In the last analysis, what makes the difference in education is how the teacher does his job. In his hands lie the realization of the goals and objectives for which youngsters go to school and the public pays. The administration, the money, the buildings, the materials, and everything else in the school system are there to give the teacher the space, means, and time to teach effectively.

Since the teacher is so critical to the educational process, it is essential for school management to know what he is doing and how well. If something is going poorly in the classroom, school management is responsible to know it and to correct it. If something is going particularly well, management must give it every encouragement to continue, and, if possible, to grow.

As a result, most school administrators find it necessary to adopt a program of appraising each teacher — to learn about his performance and to evaluate it on the basis of given standards. Appraisal is supposed to provide a continuous check on the strengths and weaknesses of the teacher: thus, management can take appropriate steps to maintain the quality level of instruction if and when any action is needed.

Teachers, on the other hand, generally don't like appraisal. They suspect any measure designed to assess the quality of their teaching, and often oppose appraisal programs. This is far from simple obstructionism; teachers recognize the administration's need to know. But, teachers have quite a stake in appraisal, too! The results are the major basis for promotions, pay raises, and, of course, dismissals. Their careers are in the appraiser's hands. If teachers are to submit to an appraisal of their performance, they have every right to make sure that the criteria and method of assessment that are used produce credible results.

This is the point at issue, credibility. Teachers say: (1) that the standards for evaluating what is effective teaching are too vague and ambiguous to be worth anything, (2) that current appraisal techniques fall far short of collecting information that truly characterizes their performance, and (3) that the ultimate rating depends too much on the appraiser. As a result, teachers see nothing to be gained from appraisal. In fact, they have become convinced that present-day appraisal practice does more to interfere with the professional spirit of quality teaching than to nurture it.

Because of these divergent views, appraisal has become a fundamental issue that has raised a wall between school management and teachers. Administrators are frustrated in getting what they believe is needed information. Teacher job anxiety increases. The situation has reached the point where more and more teacher organizations want to treat appraisal as a negotiable contract item. If the situation persists, quality education, and thus all of us, will be the loser.

The authors and their Battelle-Columbus colleagues have wrestled with this problem of teacher appraisal, looking for an answer that will satisfy both school management's needs and teachers' objections. Present appraisal practices have been analyzed critically. Dozens of school administrators and hundreds of teachers have been interviewed. The literature on learning theory, educational measurement, and child development has been studied, and specialists in these fields have been consulted. On this broad base, a method of appraising teachers has been developed that provides useful, constructive, valid information to school management on a continuing basis, and circumvents most of the factors that have disturbed the teachers.

## PROBLEMS OF APPRAISAL PRACTICE TODAY

To get firmly in mind the direction in which appraisal should go and what should be avoided, we began our work by investigating current practice, including appraisal goals, standards for measuring teacher effectiveness, and procedures for carrying out the appraisal.

### *The Goals of Appraisal*

Generally, appraisal is meant to be a quality control measure for maintaining high standards of teaching in the classroom. However, as commonly practiced, it serves too often as the basis for ranking teachers relative to merit pay, promotion, or dismissal — in reflection of someone's judgments of their teaching performance. School management, then, is judge and jury, acting on testimony supplied by an appraiser. The teacher can do little to rebut this testimony. Indeed, a teacher is in a spot much like that of an apprentice auditioning for a job as target for a knife thrower. The judgments are the knives. If the appraiser is expert, the teacher will be neatly profiled; but, if the appraiser is not so expert — well, small wonder that teachers dread appraisal.

In any case, such an approach to appraisal gives no basis for constructive action. If appraisal is used only to rank teachers and to administer reward or punishment, it rarely changes anything. The proper goal of appraisal is not only to recognize quality, but, more importantly, to increase it.

Appraisal can be used as a foundation for the professional development of the teaching staff. It can not only provide a critique of a teacher's performance, but also guide actions to improve it. Appraisal can thus be positive and progressive, rather than negative and static. Moreover, when teachers see appraisal in this light, they are bound to lose their fear and to recognize and accept appraisal as a measure useful to them as well as to school management.

In line with this thinking, the first step in developing an acceptable program of appraisal was to set as a primary goal for appraisal: *to establish a foundation for a program of professional development for individual staff members.* Achieving this goal meant that the criteria for good teaching must be

clear, definite, and objective enough to serve as effective job targets. Moreover, the methods used to identify teacher strengths and weaknesses must be accurate, and they must be acceptable to teachers. With this primary goal in mind, present-day standards and methods of appraisal were examined.

### Current Standards of Effective Teaching

In spite of the considerable research in this area, our study revealed little of value on appraisal aimed at individual staff development. Further, teacher complaints about vagueness and ambiguity of standards turned out to be all too valid.

Work on standards of appraisal has tended to focus on teachers' traits. Many of the research studies isolated such traits as understanding, cooperation, creativity, intelligence, or "has positive attitudes toward students." But the reports neglected to say what teachers *do* when they possess these admirable traits. Such findings are almost useless for identifying appraisable components of effective teaching. Since the traits are vague, evaluating them in terms of their effects upon student learning and adaptation to the culture is virtually impossible.

With such hazy standards, even the best appraiser is hard pressed to be objective; he is forced to rely on his own interpretation of what these characteristics mean in practice. The uncertainty of the appraiser's interpretation compounds the uncertainty of the standards themselves.

The methods by which the standards have been put together also are dubious. Most investigators have tended to rely on the thinking of students and supervisors. Admittedly, such inputs are important. Yet nobody can know more about good teaching than effective teachers; why should their views be so largely ignored? Moreover, the sources of information have not been tapped adequately, and not enough detail has been provided for judging the credibility of the information obtained.

Investigators have given little attention to what is known about the course of human development. The contributions that developmental and learning psychology can make to the establishment of credible standards have not been exploited fully — a serious omission. These sources can help identify types of teacher activities that are linked directly to student learning.

Finally, many of the research people in this area seem to assume that anyone who can teach can measure the results of teaching and, what's more, can use these measurements in a constructive way to improve learning. This assumption is doubtful. Teachers must assign grades, recommend promotions, and judge students high or low in many respects, but present standards of effective teaching provide little or no guidance in this function.

### Current Appraisal Procedures

Teachers have complained that the procedures for appraisal fall far short of truly informing the administration about their performance. The Battelle investigation confirms their misgivings.

Generally, teachers are appraised by matching their performance against a standard observational rating scale. The appraiser observes the teacher at work in the classroom some randomly scheduled number of times. He rates the teacher numerically from 1 to 5 for each characteristic listed on his form; the sum of these scores is the teacher's rating.

It has already been noted that these characteristics are not clearly defined, that the best appraiser has a hard time assessing them objectively, and that such a rating does little or nothing to foster improved teaching. But these facts don't give the whole story. This kind of procedure adds problems of its own that further reduce the credibility of the appraisal.

First, consider the effect of the appraiser's presence in the classroom. Teachers often act quite differently under the eye of the appraiser than they do in his absence. It takes little imagination to visualize how harrowing this situation can be. The best teachers can be nervous or defensive under the appraiser's eye, and their performance is likely to suffer accordingly.

Next is the problem of sampling. Typically, an observation schedule calls for not more than 3 classroom visits a year. These aren't enough to put into proper perspective the normal ups and downs that are characteristic of even the steadiest performers. Perhaps more importantly, with so few observations, many relevant teaching skills and learning situations will go unnoticed, even though these may be routine in the teacher's work. A teacher might well be observed to follow practices that should be improved, while those reflecting his skill are missed. With such scattered sampling, a teacher might be rated as effective, but he has to be lucky!

To make matters worse, the teacher often has little or no opportunity to discuss the appraiser's judgments. In many school districts the results of appraisal are not disclosed to the teacher. Not only may he be subjected to an authoritarian and subjective appraisal, but, to top it off, when the appraisal is completed, the teacher may have no idea where he stands. Such a practice puts the appraiser in a difficult position, too. With the assessment entirely in his hands, the appraiser must put together inadequate observation and vague standards to come up with what might well be the only opinion of record on the teacher's performance. A conscientious appraiser should balk at this situation as much as a teacher. The current system gives the appraiser every chance to make a serious mistake, but little chance to correct it.

Finally, what is left to be said for the ratings themselves? A product of disputable standards, subjective opinion, and insufficient observation, such ratings can scarcely be considered fair or helpful to teachers and, unfortunately, they can be of little use to school management, either.

## A NEW APPROACH TO TEACHING APPRAISAL

Our study of current practice left no doubt but that a workable system of teacher appraisal would have to be built from scratch. What is being done today is useful primarily in showing what to avoid. In evolving a new approach to

appraisal, the Battelle-Columbus investigators kept one goal clearly before them: the appraisal system has to serve as an instrument for upgrading the staff professionally. To achieve this end, three major elements were investigated, as described in the following:

1. *Defining effective teaching.* Past efforts to put together meaningful standards for assessing effective teaching had missed the boat because coverage of information sources was spotty and it ignored contributions from the most relevant sources — successful teachers and knowledge generated by selected educational psychologists. Exploiting these sources was considered essential to building a good appraisal system.

It was also important to avoid the vaguensss of existing standards. The most explicit statements of effective teaching were sought. For this reason, critical teaching incidents, i.e., teacher-inspired events that have a significant impact on student learning, were collected to serve as an information base. Using these as the bases for the standards averted the uncertainties tied to defining teaching quality in terms of intellectual abilities and personality traits.

About 800 usable incidents were supplied by some 465 teachers. These teachers were recommended as "best" by the administrators in the 94 Ohio school districts sponsoring the study. The incidents furnished a wealth of information about critical teacher action, and they opened our eyes to the true complexities of teaching.

Educational psychologists specialized in learning theory, child development and educational measurement were asked to review the existing literature in their fields and to extract teaching principles that would be particularly useful in the classroom. The principles submitted were then evaluated on the basis of four tests: (1) Are they adequately supported by published psychological and educational research? (2) Are they relevant to classroom teaching? (3) Are they meaningful to teachers? (4) Can the extent of their use by a teacher be assessed objectively? In checking the principles

## ILLUSTRATIVE CRITICAL TEACHING INCIDENTS

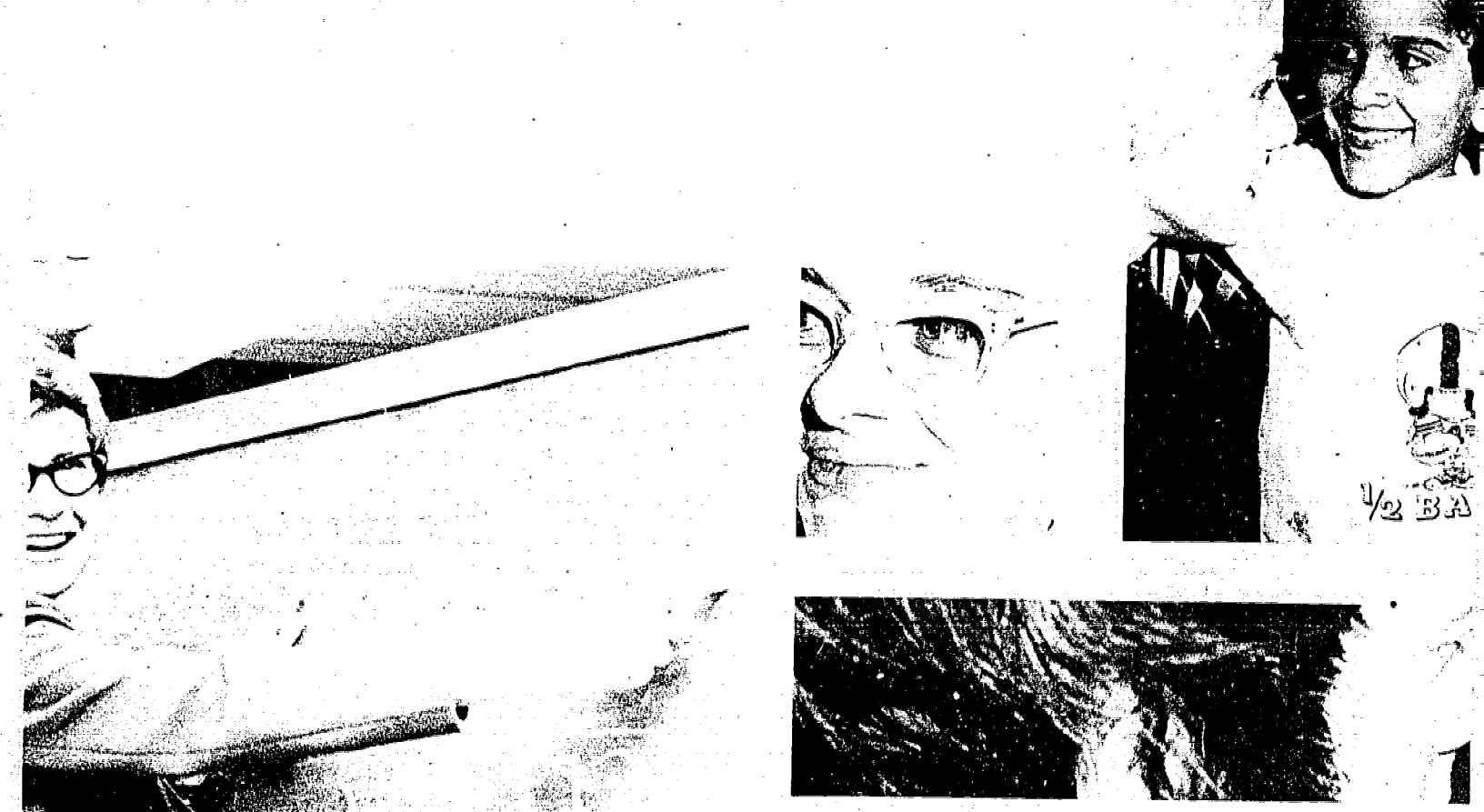
**Teacher Role:** Instructional Leader
**Category:** The Teacher Facilitates Intellectual Development
**Principle:** The Teacher Structures the Learning Situation To Stimulate Discovery, To Feed Curiosity, and To Facilitate Student Self-Discovery of Concepts and Generalizations
**Critical Incident:** The teacher of elementary science observed that his students were showing no enthusiasm. Not only did the youngsters appear bored, but they seemed not to grasp what science is all about — discovery. The pupils had begun to view science as the memorization of facts, with an occasional nature walk added.

The teacher secured 200 mealworms and placed these in a bowl on his desk. At first the children were rather fearful of these larvae, although they expressed much curiosity. The teacher refused to answer questions — even to identify the mealworms. When a child had questions, the teacher suggested possible experiments that might lead to answers, and the students began to study specimens at their desks and at home. The children began to compare results of their observations, learned the need to repeat and to control experiments, and began to comprehend the scientific process.

**Teacher Role:** Social Leader
**Category:** The Teacher Guides Peer Interactions Effectively
**Principle:** The Teacher Encourages Childhood Leaders To Be More Sensitive to Group Needs
**Critical Incident:** The teacher of a fourth-grade class saw early in the year that the more verbal students in her room not only dominated class activities but also showed unmistakable signs of snobbery in their attitude toward the less verbal or less articulate pupils.

The teacher set up a "fish bowl" discussion situation. Fourteen less talkative students were placed in an inner circle and asked to discuss why the class had been rude and inconsiderate to a substitute teacher on a previous occasion. They were expected to discuss the situation as if they were teachers. In an outer circle 14 more loquacious or more articulate students were asked to observe the interaction of the inner circle. Later the two circles switched roles. Finally, the entire class analyzed the two discussions.

The less verbal group did not talk so much, but built on each others' ideas and came to a decision. The more verbal group was so busy talking and expressing individual thoughts that they failed to listen to each other and to give support. In later discussions this group was more aware of its need to listen to one another. It also developed new respect for the less talkative students who were tempering their own thinking with the ideas of others. The teacher felt that she, too, had grown in her understanding of the class.



against the last three criteria, a group of 30 teachers from among those who had served earlier provided assistance, voluntarily.

2. *Establishing clear, meaningful standards of effective teaching.* The critical teaching incidents were examined and additional principles were extracted from them. At the same time, the critical incidents were matched with the principles to serve as illustrations. In those rare cases where no illustration was available, a hypothetical incident was created. The final product of this effort was a list of 260 teaching principles, each illustrated by one or more critical incidents.

The list was checked with the 30 teachers. Unless a large majority agreed that a principle was clear and relevant, and that its associated incident was pertinent and credible, both were tossed out. Two examples of principles and incidents are shown on the previous page.

The final list contained 241 principles. To lend coherence to this list, the principles were grouped into 20 categories, and the categories into 4 teacher roles: instruction leader, social leader, promoter of healthy emotional growth, and communicator with parents and colleagues. Some examples of categories are: under instructional leader, the teacher individualizes instruction where appropriate; under social leader, the teacher establishes a democratic classroom atmosphere; and under promoter of healthy emotional growth, the teacher reduces disabling levels of anxiety. Under the role of communicator with parents and colleagues, there is only one category: the teacher communicates information and suggestions to parents and colleagues about the intellectual, social, and emotional development of his students.

Having established standards of teaching effectiveness that we felt teachers could believe in and that could be applied objectively, we tackled the problem of appraisal procedures next.

3. *Evolving a method for self-appraisal.* If teachers are

evaluated mainly by professional appraisers, there seems to be no easy way to get around the problems of authoritarianism and inadequate observation. However, why not allow the person who is being appraised to identify his own areas of weakness? Self-appraisal not only would encourage the teacher to take steps to improve himself professionally, but also would eliminate the discomfort and/or embarrassment associated with having to listen to potentially unfavorable comments from someone else, the outside appraiser.

For these reasons, the principles of effective teaching and their illustrations were organized into a self-appraisal instrument. This has three main features: a scale that the teacher uses in rating the relevance of each principle; a scale that the teacher uses in rating his own performance relative to each principle; and a summary rating that the teacher provides for his own performance relative to each category of principles.

It is essential to have the teacher rate the importance of each principle, since its significance will vary from situation to situation, depending on the age of his students, the subject taught, the school objectives, or other factors. Consequently, before appraising himself, the teacher is called upon to appraise each principle, i.e., to determine its relevance to his situation.

Next, the teacher rates himself on each principle. Then, weighting his rating on the basis of the importance he has assigned to the principles, he computes a total or summary rating on each category. These he charts on a profile blank, which shows his appraisal of himself as against the highest level of performance he can achieve in each category. This procedure will be enlightening for the individual; but, it will discourage comparisons, since each teacher is likely to assign a different relevance value to the various principles and categories.

Here are the guidelines for using the new system:

1. *The teacher performs self-appraisal as outlined above.*

2. *The outside appraiser is brought in to serve as advisor.* Having completed the self-appraisal process, the teacher meets with the professional appraiser for the first time. In a meeting away from the classroom, they discuss and review the areas requiring improvement as tentatively identified by the teacher. Since the focus is on the performance and not on the personality of the teacher, the conferences are likely to be friendly, comfortable, and nonthreatening. Ideally, the appraiser will make suggestions that seem appropriate in helping the teacher select goals and establish priorities for improvement; he is not to dictate to the teacher. Success depends on relaxed face-to-face communication, with mutual confidence in each other's integrity and motives, and with each sharing in the decision-making and problem-solving. If a meaningful dialogue is maintained, a sense of personal achievement, a feeling of job fulfillment, and high morale will prevail. This would contrast sharply with the net effect of appraisal as it is performed these days, and would enhance the teacher's appreciation of appraisal as an authentic measure taken to aid him in his professional growth.

3. *The appraiser's classroom observations are used to provide further insight and direction.* Contrary to current practice, observation by the outside appraiser should be scheduled so that it can do the most good—by shedding light on those specific areas where problems exist and the need for improvement has been identified. Teacher and appraiser, by laying out the schedule of observations together, can bring problems into sharper focus and define directions for improvement more efficiently. Under these conditions, the appraiser will probably spend most of his observation time with new teachers or with those who have special difficulties.

4. *The appraiser consults with the teacher periodically to check his progress.* Teacher and appraiser should work together during the school year to analyze progress and perhaps to work on brush-fire problems as they arise. A final conference near the end of the year should identify new areas to be worked on in the coming year and might even develop a summer program for improvement.

## A FINAL WORD

What has been described here is the prototype of a practical system for appraising teacher performance. It satisfies the needs of management by providing a real check on the strengths and weaknesses of teachers and a mechanism for continually improving their performance. At the same time, the system eliminates the elements in current appraisal practice that distress teachers and create rifts between them and school management.

In addition to furnishing a solution to what can be an embittering situation, this approach is quite workable and creates no big administrative problems. However, the general scheme probably will need some further adjustment to iron out some roughness in its operation. While the bases for appraisal as developed here are sound, the benefits of this method will increase as the principles of teaching effectiveness and related critical incidents are refined as a result of more operating experience.

# PPBS: PLANNING FOR SCHOOLS OF THE FUTURE

*by Gerald L. Robinson*

MANY SCHOOL SYSTEMS FACE CRISES in the 1970's. Teachers demand higher salaries and more voice in decisions. Students protest for more freedom and for representation in curriculum planning. Minorities seek local control of their schools; they believe that they can educate their children better than the established system can. School requests for funds are getting chilly receptions; defeats of school bond issues have increased 70 percent in the last 5 years. Deep, far-reaching changes are called for.

How will schools manage these changes without being crippled? Solving problems of such scope and magnitude calls for skillful planning and aggressive methods for putting plans into action. Planning today must look beyond the next year. School administrators must plan with vision that is broad enough to encompass all aspects of the system. Above all, they need to set a positive direction with long-term goals and carefully specified objectives that will serve as steps to those goals.

Budgeting will be part of this planning for change. A budget should represent a means for using funds to reach goals and objectives. It's not enough just to generate a list showing the cost of salaries, textbooks, maintenance, and other inputs to the school system. Who can tell from such a budget what the spending will accomplish? Good planning calls for consideration of outputs — what can be gained from various expenditures — before funds are budgeted. Committing funds now for new buildings, textbooks, courses of study, and the like can affect educational programs for years ahead. The school administrator who plans for only one year at a time leaves himself with little leeway to consider alternatives in the future — he spends himself into a corner. Long-range planning, on the other hand, puts him in a position where he can pick from a wider range of alternatives, some of which have long lead times.

Finally, planning must provide for feedback so that better plans can be laid next year and the years after. If budget allocations merely take care of rising

costs, no real planning is being done. It is much more important to make sure that desirable, but troubled, programs are strengthened effectively and get the funds needed to bolster them. Certainly funds must be spent for those efforts that will benefit the whole system most.

Today, few schools are equipped to plan adequately. The kind of comprehensive planning outlined here calls for a system. Many educators hope that planning systems that have succeeded in industry and government will serve school management, too. Of those methods that now are under discussion, PPBS (Planning-Programming-Budgeting System) seems to have generated the greatest interest. PPBS was first applied in the early 1960's in the U.S. Department of Defense although its roots go back much earlier. Currently, a number of school districts and educational agencies are working to adapt it to school systems. Let's look at what PPBS is and how it applies.

## 7 STEPS TO GOOD PLANNING

The key element in PPBS is "planning". Basically, PPBS is a systems approach to planning that considers the costs and the consequences of using various alternatives, or options, in order to achieve the desired goals and objectives. To accomplish a school system's stated purposes, PPBS breaks down the total effort into programs, which combine related activities and resources to attain clearly stated objectives.

Budgeting in PPBS is output-oriented rather than input-oriented. This means that instead of just setting aside certain funds for teacher salaries, textbooks, building maintenance, and other goods and services, spending is planned on the basis of the results it will buy — a better driver training program, a more effective mathematics program, or a more responsive communications program. Battelle-Columbus and other specialists in PPBS are generally convinced that this planning method will improve the overall operations of a school system. However, it's not easy to set up a completely operable PPBS. This system is best adopted in steps, some of which may be expensive. Among the requirements for applying PPBS are: (1) clearly defined authority and responsibility; (2) recognition by administrators and teachers that considerable effort will be required from them; and (3) collection and analysis of substantial amounts of data. PPBS is not a programmed system to be bought off a shelf and used like many other tools. It is a systematic, rational way of planning and administering that must be learned.

PPBS should be considered as a replacement for planning methods that don't do the job needed. It's not a cost-cutting tool, per se. Rather, it offers a way of improving a school system's ability to reach its objectives within its limited resources. PPBS doesn't replace judgment; it encourages more effective use of judgment. Best of all, it can increase the effectiveness of any organization whose major concern is human values, by building these values into the goals and objectives of the organization.

What's involved in employing PPBS? For a school system, these are the basic steps:

1. Develop broad goals and objectives.
2. Design a program structure.
3. Define objectives for each program — including the means for measuring or indicating program effectiveness.
4. Identify or design alternative approaches for attaining program objectives.
5. Make cost-effectiveness analyses of the alternative approaches for each program.
6. Select the best approach for attaining program objectives and allocate funds.
7. Evaluate the results of operating each program and provide feedback to the planning process.

If PPBS is to work well, these steps have to be retraced, to some extent, each year. For the first three steps, it's mainly a matter of checking to see if any changes of direction are needed each year. The last four steps require more incisive review. For each, one major question must be answered: Are all of the involved elements still pertinent to current operations?

Adopting PPBS also makes other demands. Program budgets must be prepared for the upcoming year, and a long-range plan must be drawn up to project financial and other needs for several years. Finally, administrative structures and procedures must be organized.

The seven steps above outline the major efforts involved in instituting a complete PPBS from scratch, as a newly formed school district might. However, an established district might well approach PPBS by taking just a few programs and applying Steps 3 through 7. After gaining experience with these individual programs, it might extend PPBS into other ones and also implement Steps 1 and 2 for the entire school system. Such gradual adoption often is prudent; it allows PPBS to be established smoothly and permits the staff to be trained at a rate that keeps pace with the changes made. Each school district has to decide how best to apply PPBS. There is no one optimum way of putting it into practice.

### *Develop Goals and Objectives*

As discussed here in earlier articles, goals are broad general statements of a school system's long-range purposes. Goals are not quantifiable; they tend to be idealistic, and serve as a guide and inspiration for the school system's personnel and activities. All groups involved in and with the system should help set the goals to be sure that they reflect the overall needs and interests, and that they express the broad purposes of the system in terms that point the way to ultimate accomplishment. Goals must be relevant — not merely glittering generalities to distract people while the system goes off in other directions.

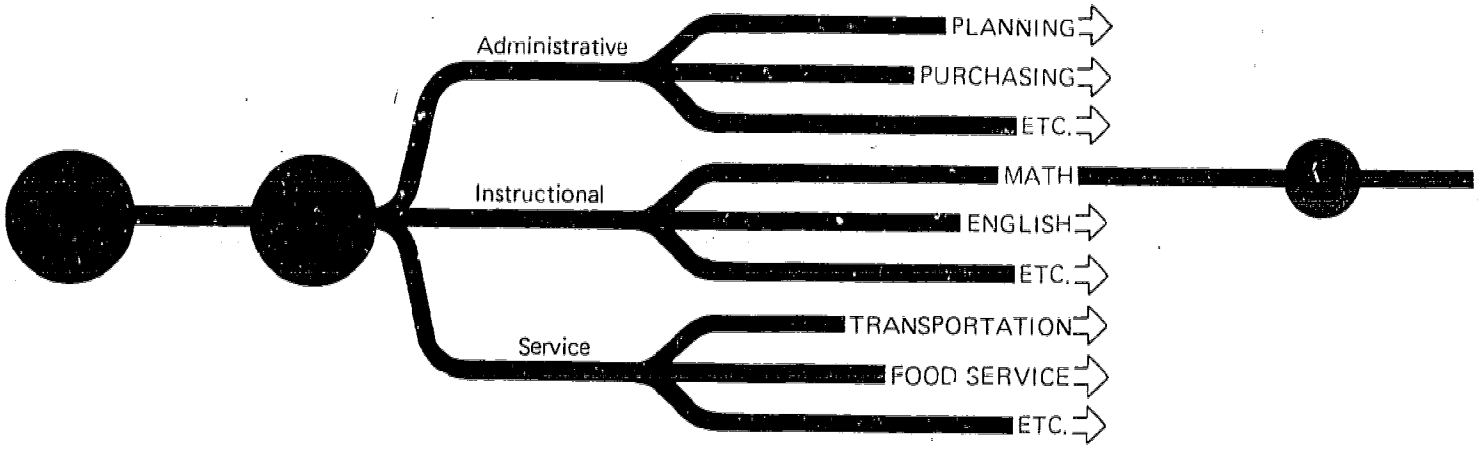
Objectives, on the other hand, are more specific statements that relate to shorter-term, attainable ends; they represent planned steps to be taken to achieve the set goals. They should be drawn up with the full participation of all concerned groups. Typical objectives would be: to reduce the dropout rate of a high school to a specified percentage, or to increase the average student score to a specific level on a particular achievement test.

Goals, then, ultimately shape the content of the curriculum, standards for the teaching staff, priorities for expenditures, and other matters so that the school system moves in the desired direction. Objectives must be carefully set to ensure the attainment of those goals.

PPBS, Step 1: Develop Broad Goals and Objectives

PPBS, Step 2: Design Program Structure

PPBS, Step 3: Define Objectives for Each Program




## *Design the Program Structure*

A program is a collection of activities and resources that contribute to the accomplishment of specified goals and objectives. A program structure, in the terminology of PPBS, is the organized listing of the titles of all the programs that comprise the school's total activities.

In designing the program structure, the planner determines the programs that will be needed to fulfill the broad goals and objectives, and he organizes the titles of these programs into an integrated structure. Related programs often are grouped into three major areas:

1. Instructional—e.g., English, mathematics, and kindergarten.
2. Administrative—e.g., central administration, planning and research, and purchasing.
3. Service—e.g., student transportation, food services, and building maintenance.

The program structure makes it possible to accomplish a number of things that are essential to applying PPBS. First and foremost, it classifies the many, varied activities of a school system into clearly identified programs that help attain specific objectives. Second, it provides a coherent basis for ultimately examining all of the programs and for allocating funds to each. It enables management to group activities and associated expenditures, so that the funding for programs can be tied to effectiveness in achieving the objectives. Third, it facilitates the assignment of responsibility for a particular program to a specific person or organizational entity.

When PPBS has been adopted for an entire school system, all of the system's activities and resources are intermeshed and pointed toward pursuing its broad goals and objectives. However, when some programs have not been organized on a PPBS basis, these must be distinguished clearly in the planning/budgeting process to ensure that they get adequate consideration.

## *Define Each Program's Objectives*

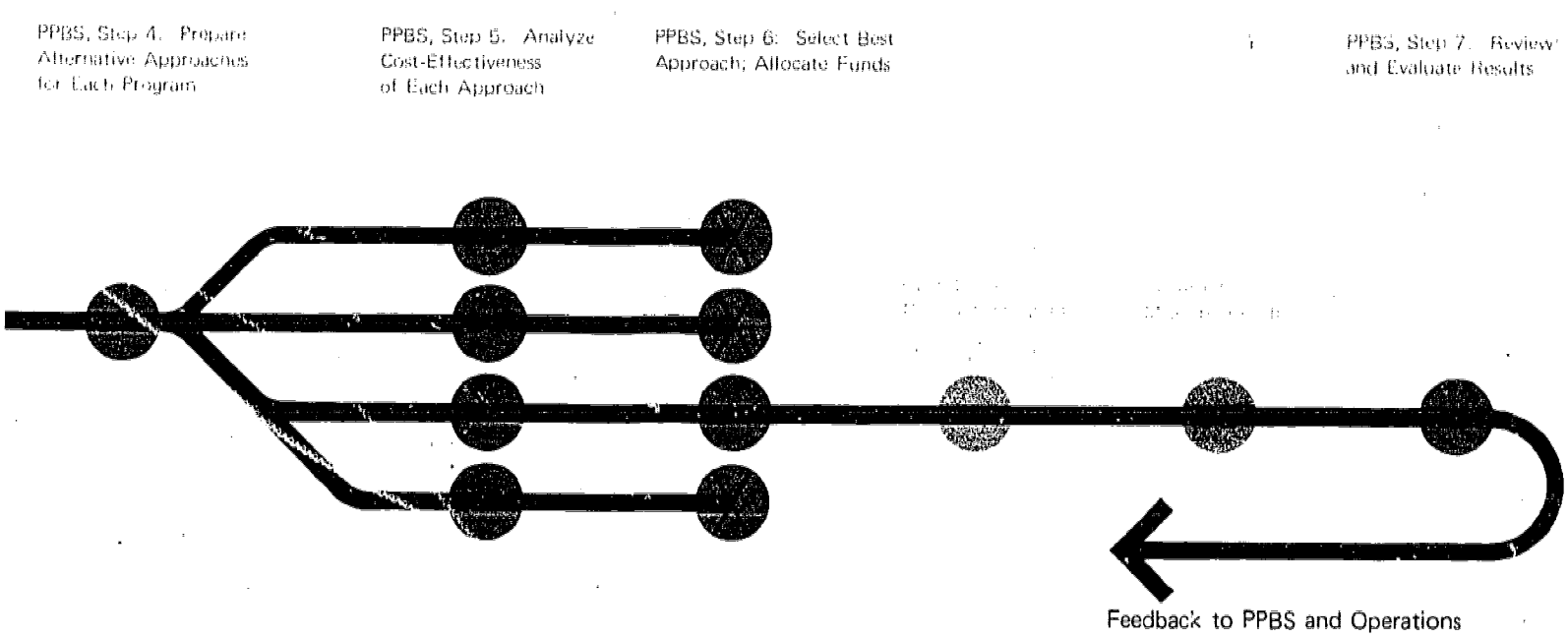
Here, the focus shifts from the integrated program structure to the individual programs. This step begins by setting up the program objectives, including the level of performance the programs will shoot for.

Posing and answering four questions can assist in defining program objectives. The questions and typical answers based on a driver training program are these:

1. *What are the goals of the program?* To train all students to drive cars safely and not be a menace to others.
2. *How is the effectiveness of the program to be measured?* By determining the percentage of students who pass the state driving test on the first try and the proportion of graduates who have been cited for traffic violations over a certain period.
3. *What level of effectiveness should be sought?* To have at least 95 percent of the students pass the state driving test on the first try, and to have the rate at which graduates are cited for traffic violations during their first licensed year be no more than half the rate for the local driving population.
4. *What constraints are likely to limit program effectiveness?* Perhaps a limited number of instructors or of cars, which, in turn, would restrict the amount of training that could be given to each student.

The relevant objective might be stated, finally, as this: to provide driver training that assures that at least 95 percent of the students will pass the state driving test on the first attempt, and to train drivers whose rate of violating traffic regulations will be no more than half that of the local driving population.

Always, the more specific the measure of effectiveness, the more useful the ob-




jective. However, since goals are not quantifiable, there always will be doubts about how far we have moved to achieve a goal when we have attained a well-defined objective. The driver training example above represents a good objective, and we can be fairly confident that the student who passes the test and seldom gets a ticket is a good driver. Nevertheless, there is the possibility that the student hasn't learned to respect the traffic laws; rather, that he has learned only to look out for the police. Judgment will always be necessary in assessing the achievement of goals; neither PPBS nor any other approach can do the evaluating automatically.

### *Generate Alternative Approaches*

Once program objectives have been defined, the next step is to identify or design various possible approaches for implementing each program. This is where the success of PPBS depends on the planner's ingenuity. Having a number of possible options does not, of course, guarantee anything, but it does give management a chance to pick the best available course of action.

Here's an example of how alternative approaches may be generated. In Ohio, approved driver education courses must provide 36 hours of classroom instruction, plus either 24 hours of in-car training or a combination of 12 hours in a car and 12 hours in a driving simulator. The following are some of the possible ways of handling the nonclassroom training for a driver education program:

- 24 hours in-car with certificated teacher
- 24 hours in-car with commercial driver-training-school instructor
- 24 hours in-car with paraprofessional instructor
- 12 hours in-car with certificated teacher and 12 hours of simulator
- 12 hours in-car with commercial driver-training-school instructor and 12 hours of simulator
- 12 hours in-car with paraprofessional staff instructor and 12 hours of simulator.

Other possibilities also might be considered. For example, when permitted by law, in-car training could be conducted on a driving range. This would allow simultaneous use of a number of cars, with a single instructor supervising the range. The student/teacher ratio would be increased, thereby reducing the costs for in-car training.

Legal limitations, public attitudes, political considerations, school policy, staff capabilities, available funds, and other factors must be considered carefully in designing alternatives. Ingenuity and creativity are essential in providing the best possible options from which to choose.

### *Analyze Approaches/Select One*

Now, how does the planner pick the best way of implementing each program? The systematic examination of the possible courses of action for achieving program objectives is of major importance in applying PPBS. Feasibility, costs, and effectiveness must be given prime consideration in judging and in selecting from the alternatives; this process is called cost-effectiveness analysis.

Analyzing the cost-effectiveness of possible courses of action can be a complicated task, requiring trained and skillful analysts. The process cannot begin until criteria have been set for evaluating the alternatives. If both cost and effectiveness are allowed to vary, comparing options becomes very complex and selection becomes largely a matter of judgment. Practically, the judging usually is done by setting either a tolerable cost or a desirable effectiveness level; then, the option that either (1) will achieve the most at the set cost or (2) will cost the least for the set level of effectiveness is picked as the best one.

Suppose, however, that the administrators haven't the data or experience of

their own on which to base predictions of effectiveness — a frequent case. What then? The most obvious step is to use specialists who are familiar with the various courses of action. Another approach is to study data and reports on the experiences of other school systems. When these are used as a basis for the analysis, consideration must be given to how a comparable program was conducted and to differences in the students, teachers, equipment, and other resources.

Costs naturally are easier to predict than effectiveness because they reflect resources used whereas effectiveness is based on results achieved. For this reason, there is likely to be a tendency to base the assessment on set financial limits. The prediction of effectiveness often depends on subjective judgment. With experience, better techniques for assessing such subjective matters will evolve; until they do, such prediction is a matter for specialists. In any case, the last move in evaluating possible courses of action is to rank the alternatives on the basis of assigned values, so that the best option will stand out clearly.

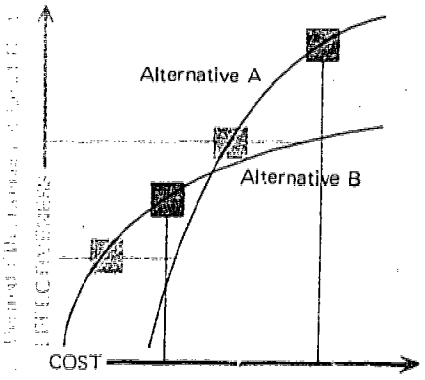
An increasingly promising way to predict costs and effectiveness more precisely is to use mathematical models. Such models can be powerful tools once they have been validated. They can be used to calculate output variables as a function of input and process variables, thereby aiding management in choosing effective and efficient alternatives.

Cost-effectiveness analysis does not make decisions. It does supply information that increases the decision-maker's knowledge, and it sharpens his judgment by reducing uncertainties. But other unmeasurable factors must be considered — e.g., political climate, community goals, and economic conditions. Only the individual or group that ultimately is responsible for results — like the superintendent or the board of education — should make the final decisions.

### *Evaluate Each Program's Results*

Though review or evaluation of a program's operation is not always listed as a part of PPBS, it is essential. It is this feature that makes PPBS responsive and flexible. Moreover, it must be done by the end of each planning period since it provides the feedback that is needed to adjust and improve goals, objectives, program structure, or the programs themselves during the next planning period. Without this review, management lacks effective control over operations.

Management review and evaluation are basically a matter of comparing actual results with the stated objectives. The results must be measured using the same standards that were employed in defining the objectives. If a program's results are unsatisfactory, either the program must be redesigned or the aspirations stated by the program objectives must be trimmed. Wherever possible, management should exercise control of programs by evaluating them frequently or continually, rather than only at the end of the planning cycle.



Greatest Effectiveness at Set Cost

## PPBS AND THE SCHOOLS

PPBS is really only beginning to enter the school scene. Battelle-Columbus specialists recently surveyed over 40 school districts throughout the nation that have started to use PPBS. Although none of the 32 school districts that returned completed questionnaires is operating completely under PPBS, several districts are well on their way.

The evolution of PPBS for use by many school districts is moving forward. The Research Corporation of the Association of School Business Officials is conducting a project for the U.S. Office of Education, to develop a "program-planning-budgeting-evaluation system design" for local schools. Under a U.S. Office of Education grant, the University of Pennsylvania has developed an education - planning - programming - budgeting system for the public schools of 6 counties in Pennsylvania. The California State Department of Education is sponsoring work on a conceptual PPBS design for California school districts. Battelle-Columbus currently is investigating PPBS for 90 Ohio school districts; one district has joined with Battelle in a pilot study, and a number of other districts will participate through an advisory council.

In spite of the problems associated with setting up PPBS, school systems are expected to employ it increasingly in the years ahead. As the top people in school systems realize, management and planning are difficult at best. PPBS will not make these activities easy, but it will make them more fruitful. With PPBS, school leaders not only can plan more effectively, but also can be much more successful in reaching the goals and objectives.

As more schools turn to PPBS, approaches to implementing it are expected to improve. Moreover, developments in such areas as learning theory, educational indicators, measurement techniques, organization theory, and predictive models will ease the rigors of implementation and increase the value of PPBS to the schools.

# A BETTER SCHOOL/COMMUNITY DIALOGUE

*by Dionne J. Marx and Robin J. Milstead*

In today's highly complex, urban, and pluralistic society, the schools often are immense organizations representing several consolidated districts. The days of small schools serving rural, homogeneous communities have passed. The managing of schools has moved from the hands of parent and interested citizen groups to the desks of professionals. The curriculum has advanced beyond the 3 R's to intensified courses in science and mathematics, social studies, and vocational training. Likewise, communication between the school and the community has evolved from informal conversations at neighborhood gatherings and church socials to more formal modes, such as news media, PTA meetings, and lengthy annual reports published by the schools.

The critical problems thrust upon our educational system recently have awakened many educators to the urgency of a good school/community dialogue. Abruptly confronted by the public's growing disenchantment and concern with school practices and expenditures, educators are beginning to look seriously at their communication programs.

## TROUBLES IN COMMUNICATING

School/community communications have two broad goals: (1) to make the community aware of the policies and practices of its schools and the reasons behind them, and (2) to determine the opinions and expectations of the community relative to education.

As of now, it is rare for either goal to be achieved. Most educators realize that good school/community relations require good communication, but few have done anything about it. Hence, too frequently, lack of information about the schools has bred dissatisfaction in the community, and lack of knowledge about community composition and feelings has contributed to poor planning by the schools.

One of the most prevalent problems is that communication between school and community has not been a two-way exchange. The current thinking on school/community communication proposes that it is everyone's responsibility to establish rapport among the home, the school, and the community. However, in practice, communication policies have been basically a school managerial concern, with the school administrator serving as the initiator and director. Most school districts have relied on a limited flow of selected information in one direction only—the school sending and the community receiving. Too often the schools have transmitted only the information they wished the community to have, with little regard for what the public really wanted or needed to know. Students' report cards are a good example. Grades for achievement and marks for behavior are readily given out to parents. But the report cards seldom include explanations for these grades and marks. Parents who ask "Why?" often find that administrative ears don't hear the question.

Good communication means listening as well as talking. The schools should listen to how the community feels about its schools and what it expects from them. The responsibility for this dialogue does not belong entirely to the school; community leaders, parents, and other interested citizens must join in. Too often, gossip, complaints, and other forms of public expression have not been translated into constructive statements, and community leaders have not always extended themselves effectively to coordinate needed community action.

Another major difficulty is that, when the schools try to reach the community, their efforts frequently are spotty and unrealistic. The tendency is to get word to the public only during crises, such as last-minute attempts to pass tax levies, or once-a-year meetings to quell student protests or to resolve the parents' smoldering criticism of the schools. Beyond this, the schools tend to limit their messages to occasional rosy reports of how well everything is going. Such slipshod communication leaves fertile ground for public discontent, which often shows up in the defeat of tax or bond issues or in community pressure to oust school officials. If educators expect public support, they need to disseminate systematically the kind of information that pinpoints a school's needs and weaknesses as well as its successes.

Further, educators disagree on the need for communication programs and on who should implement them. Few schools have taken time to specify objectives for such programs, and even fewer have set up procedures to evaluate progress toward the objectives. Also, not many educators are familiar with public relations techniques and how to implement them. The communication programs that do exist rely on the efforts of various staff members, working informally and part time. Many administrators assign these duties to someone whose work load seems light — with little regard for the personality or skills needed. Few school systems have considered hiring a professional full time. Further, most school administrators view communication materials and personnel as luxuries and seldom plan for them in school budgets.

Likewise, educators' attempts to inform the community often have failed because they didn't communicate at the proper level of understanding or they didn't use the community's natural channels. Educators frequently have little insight into the composition of their community. They have not paid enough attention to the various ethnic and socioeconomic groups and to the different publics of the community, e.g., parents, businessmen, and senior citizens. Too often it takes a crisis to make an educator realize that each group responds to and evaluates the school according to its own interests and needs.

Finally, there has been a dearth of research on school/community communication. Most surveys of the community's desires and preferences or evaluations of communication efforts

have been done by untrained personnel at the local level. Without the professional guidance required, these activities often have lacked the necessary methodology, and thus the findings and results have been, in the main, relatively useless.

## THE SCHOOL TALKS TO THE COMMUNITY

The first goal of school/community communication, to tell the community about the schools, can be achieved through a number of approaches. All of them require some expertise, at least for initial advice and guidance; but once formulated, the approaches can be implemented fairly easily by a local school district.

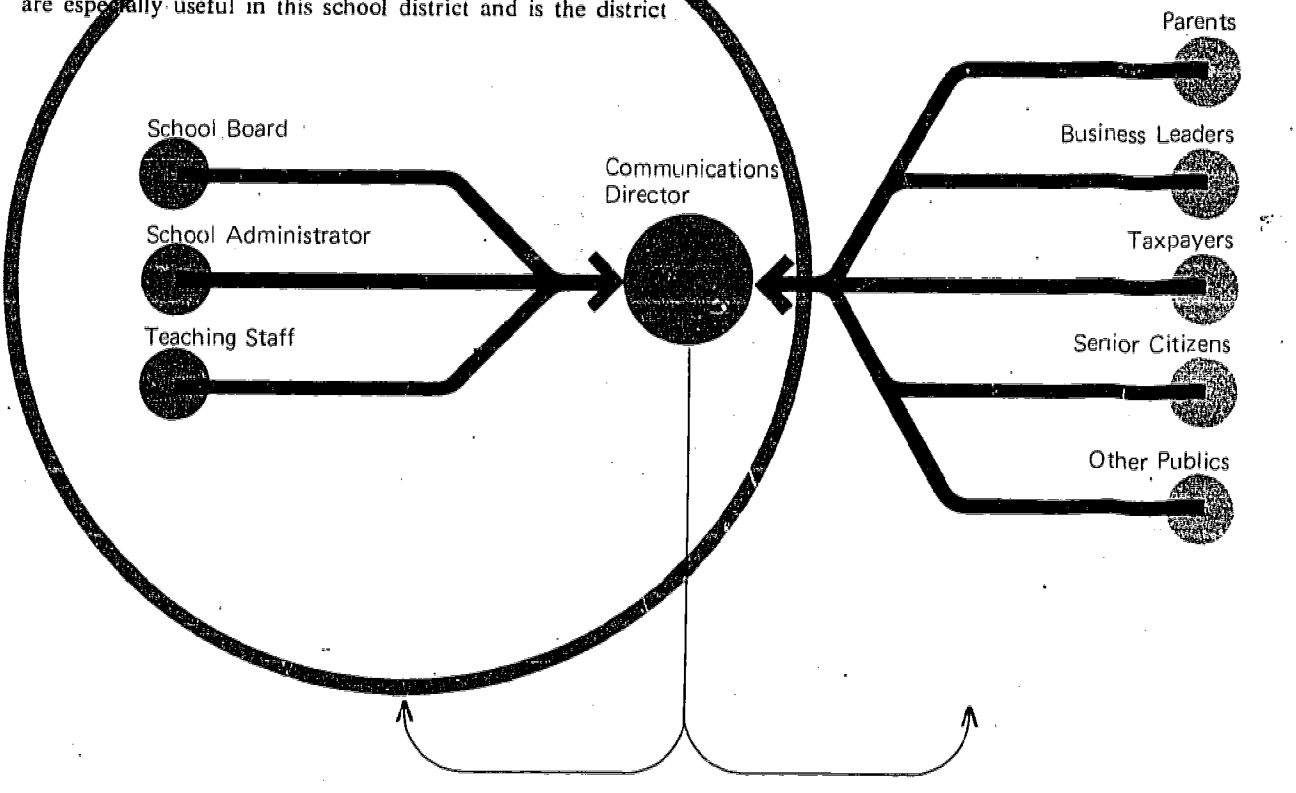
Developing communication guidelines for both school and community is one approach that specialists in school/community relations have found to be successful. This type of guide points the way for administrators, teachers, school boards, and communication staffs in regard to such factors as paths for communicating with various interest groups in the community, procedures for using the news media, and suggestions on how to handle crisis situations with the public in the event of communication breakdowns. Community leaders and interested citizens can also employ such a guide to learn how to communicate effectively with the schools, how to find lines of access to the decision-making process of school management, how to move other publics in the community toward coordinated action in education, and the like.

Another approach is to bring in a research team to appraise the current communication program and make recommendations for improvement. Such a team could examine where the program fits in the overall scheme of things, what it hopes to accomplish, how it is being conducted, who is conducting it, and what it might achieve if resources and personnel were used differently. For example, one question the team of specialists might ask is this: What channels of communication are especially useful in this school district and is the district using them as effectively as it might? The specialists might find out that a large district could employ the mass media to advantage, and they might suggest how the district might exploit, say, regular television programming. Or, they might focus the attention of a small district on person-to-person means of communication such as telephone hours or open houses that would put the people of the community in direct contact with school administrators. Recommendations of such teams could either point out possibilities or develop complete program outlines, depending on what the school districts want.

Workshops led by professionals provide another means of improving school/community dialogue. They furnish collective opportunities to exchange and generate ideas, information, and solutions to communication problems. Workshops can be organized either as part of the school's in-service training or as a special project sponsored by a local, regional, or national educational association. Such workshops or seminars usually instruct attendees in describing school policies and programs, and the reasons behind them, to the various publics in the community. Techniques are explained on how to communicate the school programs broadly enough so as to emphasize their importance to the entire community as well as to the specific publics. Training also can include how to convey a school's financial needs to the community and how to publicize the rising cost of education using reports, meetings, and the news media. Finally, such seminars can teach school officials how to budget funds for communication.

## THE SCHOOL LISTENS

If the school is keeping the community informed of its plans, needs, and activities, this is noteworthy; but, the school still may be doing only half a job. As we have em-




A PLAN FOR SCHOOL/COMMUNITY COMMUNICATIONS

phasized, two-way communication is essential, and the school must give equal attention to realizing the second goal of school/community communication: to determine the community's opinions and expectations in regard to its schools.

In many ways, this second goal is tougher to achieve than the first. Getting reliable, representative information from the community is a sophisticated task. It calls for special techniques used systematically by trained communicators. Past efforts of school systems indicate clearly that: (1) some method of surveying the community is necessary, and (2) the method must be developed for and by the community, and must be tailored to satisfy the needs of that community.

To perform this important task, the mechanism of communication between the community and the school must give information not only on broad goals, but also on more specific aspects of the educational system that concern the various publics. Students and parents are concerned about such matters as whether vocational training is to include just woodworking and home economics, or also the development of entry-level job skills that would qualify a student for work once he completes his formal education; whether driving courses are offered, graduates are readily accepted by universities, lunchroom services are provided, or students are bussed; or what kinds of teachers are hired. Setting up means of getting community views on all such questions is most important in shaping the school objectives and in formulating the programs.

In this connection, Battelle-Columbus specialists are just completing the development of a survey method that is expected to tap these community views. This method is designed to accomplish two tasks: (1) to enable the people of the community to state the goals and objectives that they want the schools to achieve, and (2) to tell school management how well or how poorly they think the schools are performing.

Interviews of people representing the various publics in a number of Ohio communities provided several thousand statements of what the people wanted and expected from their schools. Based on these statements, a survey instrument was devised. The goal statements were categorized according to the school-related areas that they touched on, and values and priorities for these statements were established using a scaling technique. Typical of the diversified areas that the instrument covers are questions relating to: the elementary curriculum, financial support for schools, student discipline, vocational education, duties of school board members, racial integration, and the role of state government.

Each step in the preparation of the survey instrument was taken with the help of people from the cooperating school districts. The widest possible participation was employed to assure that a representative array of viewpoints would be covered. Populations were sampled in regard to age, race, geographical location, occupation, income, education, religion, and size of family. In all, the community was approached four times: once for the collection of goal statements, twice during sorting and scaling of these statements, and finally for a demonstration pilot run of the survey.

The survey instrument was constructed so that a school's administration, at will, can employ the whole unit or only parts of it, depending on the particular subject area or areas in


which the voice of the people is to be tapped. For example, if the school superintendent wishes to assess public opinion regarding an impending bond issue, he can submit the finance portion of the survey form to the entire community or to a specific sector of the people, and thus get information in that area only.

Even the results obtained during the development of the survey instrument, particularly the findings from the pilot run, will give school management significant insight into the makeup of community interests. This pilot run tells a lot about how various groups in a community react to school policies and practices. When interpreted in the light of what an administrator knows about the population composition of his school district, such data can help him estimate the kind of support he can expect from various community groups.

Although the Battelle survey instrument is expected to serve most school districts as a basic tool for monitoring public opinion effectively, it should not be relied upon to provide the only input. Schools also should stay alert and sensitive to the voices of students, parents, community leaders, and citizens-at-large.

## KEEP IN TOUCH

To attack the problem, attack the cause. Inadequate school/community communication is not the only cause of the problems that beset schools today, but it certainly is one of them. Moreover, it is a situation that must be corrected before other causes can be attacked effectively.

Schools need help in establishing effective communication programs or in upgrading their current ones. Behavioral scientists have addressed themselves to the problem and have worked out a variety of approaches; the Battelle survey instrument is one example of their efforts.

The need for communities and schools to unite their resources and efforts toward achieving the best in school/community communication is a challenge and an opportunity for contemporary society. Educational problems, like other social problems, are best solved by people working *together*, with each participant contributing his creative ideas, professional knowledge, and personal efforts. To communicate is to share oneself with another, leading to mutual understanding and ultimately to the cooperative solution of shared problems.

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## FOR FURTHER READING

The literature on education is vast and some of the classics were written a century or more ago. Educators who are interested in updating schools can learn from the American classic **Democracy and Education** by John Dewey (Macmillan, 1916). It advocates children learning to work together in preparing for citizenship and teachers guiding them by promoting cooperative inquiry. Neil Postman and Charles Weingartner's **Teaching as a Subversive Activity** (Dial Press, 1969) supports an inductive approach to learning that emphasizes problem-solving rather than memorizing by students. The authors are highly critical of conventional teaching and school organization patterns. Readers concerned with planning and achieving systematic changes in education will find that **The Planning of Change: Readings in the Applied Behavioral Sciences,** edited by Warren G. Bennis, Kenneth D. Benne, and Robert Chin (2nd edition, Holt, Rinehart and Winston, 1969), is quite helpful. G. Immegart and F. Pilecki in **An Introduction to Systems for the Practicing School Administrator** (Rand McNally, 1970, in press) clearly characterize the systems movement and its relevance to educational reform.

Schools need the benefits of both scientific and humanistic management. How educational leaders can combine these two into a participative system is the focus of **The Human Organization: Its Management and Value** by Rensis Likert (McGraw-Hill, 1967). George S. Odiorne's **Management by Objectives: A System of Management Leadership** (Pitman, 1965), though written for business and industry, is highly recommended for educational management also.

While educational technology has been written up extensively, a particularly good account of current approaches is given by David L. Cram, et al., in **Principles and Practices of Instructional Technology** (General Programmed Teaching, 1969). Robert F. Mager, in his small book **Preparing Instructional Objectives** (Fearon Publishers, 1962), presents a most readable and authoritative statement on how to write instructional objectives. The steps taken by schools to individualize instruction can be examined by reading Thorwald Esbenson's **Working With Individualized Instruction** (Fearon Publishers, 1968), which covers the efforts in Duluth, Minnesota, and by listening to "Individualized Instruction," edited by William Deterline, in **Sound Education Reports** (audio tape), Vol. 1, No. 11, 1970, which relates to two other experiences.

Since many of the published writings on teacher appraisal suffer from the defects outlined in the article here, the literature in this area should be approached carefully. A. S. Barr's **Wisconsin Studies of the Measurement and Prediction of Teacher Effectiveness** (Dunbar Publications, 1961) provides a fine general critique of current appraisal practice. Related problems and controversial aspects are analyzed critically and interestingly by Donald U. Medley and Harold E. Mitzel in "The Scientific Study of Teacher Behavior," **Theory and Research on Teaching,** Arno A. Bellack, editor, p. 79-90 (Teachers College Press, Columbia University, 1967). George B. Redfern in **How To Appraise Teaching Performance,** p. 15-22 (School Management, Inc., 1963), discusses the appraisal goal of teacher development and its achievement. Using critical incidents as a base for defining effective teaching is described by David G. Ryans in **Characteristics of Teachers: Their Description, Comparison, and Appraisal,** p. 79-83 (American Council on Education, 1960).

While educational applications of PPBS are relatively new, there are several helpful books on the subject. Probably the best of all is Harry J. Hartley's **Educational Planning-Programming-Budgeting, A Systems Approach** (Prentice-Hall, 1968). A general approach to cost-effectiveness analysis is given in **Cost-Effectiveness Analysis, New Approaches in Decision Making,** Thomas A. Goldman, editor (Frederick A. Praeger, 1967). M. B. Carpenter and S. A. Haggart report on concepts, techniques, and problem areas associated with analysis of educational programs in **Analysis of Educational Programs Within a Program-Budgeting System,** (Rand Corporation, September, 1969). The experiences of a Skokie, Illinois school district in implementing PPBS are recounted by Wesley F. Gibbs in "Program Budgeting Filters Down to Education," **Nation's Schools,** November 1968, and by others writing in the same issue.

Not much has been published on school/community communication. However, the 5-volume report, **The Structure and Process of School/Community Relations** by Richard F. Carter, et al. (Institute for Communication Research and School of Education, Stanford University, 1966), is a valuable general source of information. Martin Buskin's article, "How Do You Make People Give a Damn?", **School Management,** May, 1969, p. 45-50+, tells about the impact of a dynamic, new school official upon a degenerating school district. How a public relations professional can help a school's communication program is portrayed in "What Can a PR Man Do?", **School Management,** May, 1969, p. 96-100. Robert E. Jennings and Mike M. Milstein, in "The School Budget, Achieving Public Support for Education," **The Clearing House,** April, 1969, p. 458-462, illustrate the utility of effective school/community communication in solving an eminently practical problem.

# The Authors

**Dr. William D. Hitt,** director of Battelle's new Center for Improved Education. With a background rooted in the behavioral sciences, he has been deeply involved in applying the concepts and methods of those disciplines to the solution of social and educational problems, especially where technology may enter as a factor. At Battelle-Columbus, Bill has concerned himself with both the planning and management aspects of education. This experience has led to his present special interest in promoting a better relationship between humanness and technology as a means of creating more effective schools.

**Ronald J. Cress** concentrates on research in experimental and learning psychology, particularly on applying educational technology. At Battelle, Ron's experience has ranged from using programmed instruction for training in retail sales and repair of electronic units to creating high school curricula, and from developing guidelines for a model school to working on programs of education and training relating to the urban environment.

**Robert F. Rubeck's** primary interests are designing educational training programs and employing specialized visual aids in education. He has served several school systems as curriculum consultant, has developed and conducted a training program for curriculum-design personnel, and has instructed educational administrators in business management concepts.

**Robin J. Milstead,** a psychology graduate who started out to be an engineer, has worked on the social problems of juveniles, welfare, and drug abuse. These activities have included research on bridging the economic gap between students from lower and middle socioeconomic groups, education in correctional institutions, and problems of school/community relations.

**Dionne J. Marx,** with background in psychology and sociology, has investigated the training needs of a brokerage firm, the operation of a blood bank, and the role of large companies in developing industries in the inner city. Currently, she is guiding a study of the public's educational goals and objectives, and also is examining the educational needs of inner-city residents.

**Gerald L. Robinson's** areas of special interest are operations research, management science, and industrial engineering. His studies have included applying the Planning-Programming-Budgeting System (PPBS) to school systems, analyzing recommendations for improving business operations in Ohio schools, determining business's role in inner-city economics, and managing production and inventory. Earlier, Gerry held positions in engineering planning and administration with several industrial firms.

**Dennis N. McFadden** is concerned with educational evaluation and measurement, experimental design and statistics, and developmental psychology. He has evaluated apprenticeship training in the building trades, analyzed Ohio's vocational needs, studied the characteristics of pre school education, and directed the teacher appraisal study. Before coming to Battelle-Columbus, Dennis was a fellow with the Educational Testing Service.

**Kara** will soon enter school having already shown that she can catch lightning bugs, build sand structures, and operate small cars. Her responsibilities will include absorbing information and learning to use it in the real world. Kara is not an author. She, and many others like her, are what the articles are all about.

**Dr. E. Allen Schenck,** a specialist in experimental design and measurements in education, was assistant professor of psychology at the University of Illinois before joining the staff. Allen has contributed to studies on a rationale for preschool education, effects of education on students' intellectual growth, and techniques for teacher evaluation.

# Selected Staff Publications

**Housing—A Basis for Providing New Opportunity to America's Poor.** Why not open the door for low income families to learn new skills, obtain income from new jobs, and improve living conditions in their own neighborhood, instead of uprooting them and forcing them into an alien environment? More specifically, why not provide jobs, incomes, housing, and opportunity for self improvement in selected rural areas as well as in urban areas? Battelle has been conducting an experimental demonstration program using low-cost housing as a vehicle for longer-term social and economic development in South Dakota. The selection of families and house design, the materials used, and the cost are described. **John R. Hagely,** in *23rd Annual Short Course In Residential Construction,* University of Illinois Bulletin, v. 65, no. 122, June 5, 1968, p. 40-47.

**Water Resources Systems Analysis — An Overview.** Recent work on the systems analysis of water resources is summarized briefly. The author discusses the basic elements of specific systems-analysis techniques, the inherent features of each system that make it useful in designing and analyzing water resources systems, and the aspects of water resources problems that make them amenable to study by systems analysis methods. Model structure is emphasized. **Neil L. Drobny,** in *Proceedings of the Fourth American Water Resources Conference.* 1968. 34 pp. American Water Resource Association.

**Science for Society: A Bibliography.** This listing of writings on technologically initiated problems and how society can move to bring about their solution has been issued as an aid to educators. It covers a variety of problems including: population, agriculture and food, pollution, health, natural resources, race, biological engineering, science, and war and peace. Battelle has joined with the American Association for the Advancement of Science and the National Science Foundation in supporting publication of this bibliography. This step underscores the belief that a multidisciplinary attack is necessary to solve contemporary problems. **John A. Moore,** for the Commission on Science Education of AAAS. AAAS Miscellaneous Publication 70-6, BMI Special Publication 70-1-50. 1970.

**Civil Systems in Urban Transport Decision Making.** Public approval of major new urban transport systems hinges on sound technical planning, appropriate legal and financial mechanisms, and forceful working coalitions of key community groups. Experience in the development of transport systems throughout the U.S. suggests that the workings of such coalitions (called "civil systems" here) are the least understood aspects of the development process and, perhaps, the most important. The author evaluates the structure and the dynamics of community coalitions on the basis of survey data from 7 urban areas across the nation. **C. William Hamilton.** *High Speed Ground Transportation Journal,* v. 4, no. 1, Jan. 1970, p. 81-102.

**Development of Materials for Use in Circulatory Assist Devices.** The goals of this research program are twofold: (1) to modify materials to produce nonthrombogenic surfaces, and (2) to study the basic interactions occurring at the blood/foreign surface interface. Work has been done on the modification of synthetic polymers by attaching heparin to their surfaces chemically. Techniques developed involve both ionic and covalent bonding of heparin to a wide variety of polymers, including those currently used for prosthetic devices. **Gerald A. Grode, Richard D. Falb, and Sandra J. Anderson,** in *Artificial Heart Program Conference, Proceedings,* p. 19-27, 1969.

**Reliability Analysis Techniques.** Various methodologies for predicting and analyzing the performance, reliability, and cost factors of electronic circuits have been developed under Federally funded programs. The techniques summarized here apply also to the design of consumer products. **Robert A. Yereance.** *Appliance Engineer,* v. 4, no. 1, Feb. 1970, p. 40-43.

**Reducing Pinhole Porosity in High-Alloy Steel Castings by Additions of Selenium.** Pinhole porosity in green-sand-mold castings has troubled high-alloy steel foundries. This type of porosity shows up as elongated, irregularly shaped holes just below the surface of the casting, with the long axis of the holes roughly at right angles to the surface. After discussing the theory of pinhole formation, the authors describe a method for reducing pinhole porosity by adding selenium to the steel. **A. M. Hall and Clarence E. Sims.** *Metals Engineering Quarterly,* v. 10, no. 1, Feb. 1970, p. 53-55.

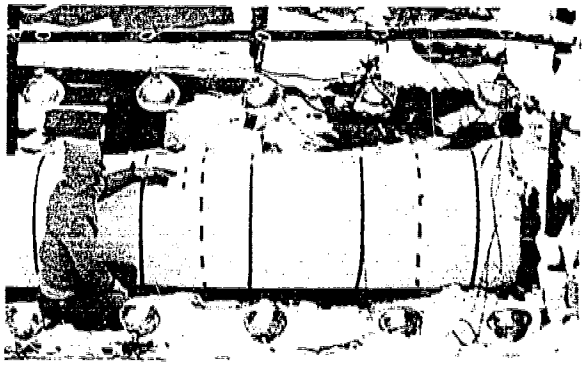
**Put Input-Output in Your Future.** Our economy is made up of a complex matrix of supplier/customer relationships among all industries. In the past, input-output charts were a record; now they are becoming forecasting tools. Input-output is a term resulting from studies of the interrelationships among segments of the economy. Some companies are using input-output to project the future economy; several organizations already have constructed input-output tables — in Battelle's case, for 1975. **W. Halder Fisher.** *Industry Week,* v. 166, no. 2, Jan. 12, 1970, p. 40-42.

**Early Warning Systems Concerned With Environmental Contaminants.** The magnitude and seriousness of environmental problems affecting man require changes in many current practices. Man must have the insight to visualize situations that may be hazardous, and to initiate research and control programs before the situations reach critical proportions. Such action requires establishing information analysis centers that are mission-oriented to environmental problems, to provide the basis for identifying and systematically evaluating the situations. **Frank A. Butrico.** *American Journal of Public Health,* v. 59, no. 3, Mar. 1969, p. 442-447.

**Some Approaches to Character Recognition for Postal Address Reader Applications.** There are several approaches to recognizing machine printed characters of a quality commonly encountered in postal addresses. Generally, these approaches reflect two different recognition concepts. One exploits certain properties in the underlying geometry of the characters. The other emphasizes the statistical aspects of the characters taken collectively. **Evan L. Brill, Richard P. Heydorn, and J. Douglas Hill,** in *Proceedings of Automatic Pattern Recognition,* 1969, Post Office Department, Bureau of Research and Engineering; National Security Industrial Association; and Institute of Electrical and Electronic Engineers.

**U.S. Navy Diving-Gas Manual.** This is intended for use in research on diving and in designing and operating diving systems. For the first time, data are made available on the properties of helium/oxygen mixtures and pure gases used in breathing mixtures that are suitable for saturation diving. The manual shows differences between real-gas properties and perfect-gas behavior at higher pressures; it presents charts and methods for selecting breathing gas compositions and flow rates for different types of diving gear; and it supplies humidity data for various gas mixtures and pressures. **Herbert R. Hazard, Joseph F. Walling, et al.,** U.S. Navy Supervisor of Diving Report No. 3-69, AD-701566. (CFSTI)

**Control of Research and Development Costs.** The financial executive does not "control" research costs. He furnishes correct and current cost information to the research manager just as he does to the production and marketing managers, and cooperates in preparing estimates of the financial aspects of possible future actions. He is part of the top management team and summarizes the projected financial results of decisions made by the vari-



**Crack Propagation in High Pressure Pipe.** This section of steel pipe is being instrumented for full-scale studies of crack propagation in high pressure pipelines. Internal pressure initiates fracture at a preset notch. The characteristics of the moving fracture are then recorded by various means, including high speed photography. The experiments, their results, and some engineering interpretations for fracture-safe design are discussed in the paper by **Arthur R. Duffy, Robert J. Eiber, Willard A. Maxey, and George M. McClure.** "Research on Steels for High-Pressure Pipelines," in *Proceedings of the 1968 Pipes and Pipeline Engineering Convention*, 1969, 35 pp.

**Clues to Bioprocesses From Thermal Analysis.** A biological specimen is being placed on the sample pan in preparation for a differential thermal analysis (DTA) experiment to study water in tissue. DTA is one of several types of thermal analyses that have been found useful in biological applications. To summarize the various ways that thermal analysis can be used in biological research, **Robert W. Pfeil** reports on Battelle sponsored experiments and draws examples from recent literature in his paper. "Biological Applications of Thermal Analysis," in *Proceedings of the Third Toronto Symposium on Thermal Analysis*, 1969.

**Microencapsulation.** This Battelle-developed fluidized bed apparatus can encapsulate a myriad of materials, solid or liquid, in one continuous operation. It represents one of several techniques that can be used to encapsulate particles ranging in size from a few microns or less to about 2000 microns. Other processes of this kind include aqueous phase separation, nonaqueous phase separation, interfacial polymerization, use of multiorifice rotating cylinders, melt prilling in a fluidized bed, spray drying, diffusional exchange, and meltable dispersion. These techniques and their application are considered by **Herman Nack** in his paper "Microencapsulation Techniques, Applications, and Problems. *Society of Cosmetic Chemists, Journal*, v. 21, no. 2, Feb. 4, 1970, p. 85-98.

ous components, including the research group. A variety of functions are discussed; the author does not imply that the financial executive performs all of them. **Paul R. Langdon**, *Financial Executive's Handbook*, p. 664-681, 1970. Dow Jones-Irwin, Inc., Homewood, Illinois.

**Ecological Transfer Mechanisms—Terrestrial.** Radionuclides that are released to the environment by nuclear-excavation detonations may enter a variety of biogeochemical cycles and follow essentially the same transfer pathways as their stable element counterparts. The generalized materials-transfer diagram presented is applicable to the forest, agricultural, freshwater, and marine ecosystems that provide food and water to the people in the regions of Panama and Colombia where nuclear excavation of a sea-level canal could have an effect. Mechanisms for transferring stable elements and radionuclides in terrestrial ecosystems are discussed. **Wiliam E. Martin, Gilbert E. Raines, Sanford G. Bloom, and Arthur A. Levin,** in *Proceedings for the Symposium on Public Health Aspects of Peaceful Uses of Nuclear Explosives*, 1969. 28 pp.

**Columbium.** This metal more than doubled its volume in the 1960's, based on its use in aircraft turbine superalloys, special construction steels, automotive and machinery alloy steels, and stainless and heat resistant steels for the chemical processing and automotive industries. The demand could well double again during the seventies, perhaps expanding 60 percent by 1975. Columbium production, consumption, and prices are discussed. **Frederick H. Buttner.** *Engineering and Mining Journal*, v. 171, no. 3, Mar. 1970, p. 130-133.

**Boundary Layer Lubrication: Monolayer or Multilayer.** Some of the literature on the properties of liquids squeezed between two solid flats and on related data are reviewed critically. Most of the data seem to be qualitatively valid. The simplest and best way of accounting for the observed results is to postulate the existence of a film with properties far different from those of the bulk liquid. The best model found for such films is an ordered-liquid model in which the wall forces, though not strong enough to bind more than a few layers, induce long-range order in the fluid. **C. Malcolm Allen and Edmund J. Drauglis.** *Wear*, v. 14, no. 5, Nov. 1969, p. 363-384.

**Cost Estimating and Production Planning at the Preliminary Design Stage.** A computer program has been developed to estimate the fabrication and materials cost for the inert components of rocket motor cases. The program is planned to provide cost estimates accurate enough (within 10 to 20 percent) to be useful in the early stages of a design. The estimates permit the designer to compare various rocket designs that promise optimum performance, to determine which design could be produced at least cost. **Daniel E. Strohecker.** *Technical Paper No. MM70-724*, 11 pp., 1970. Society of Manufacturing Engineers.

**Electrical Contact Materials for Space Applications.** The performance and reliability of electrical contacts are determined largely by reactions at the contact surface. These reactions depend on the contact material, the chemical environment in which the contact device operates, and how the contact device works. The significance of surface reactions relative to performance and reliability is often established by the electrical requirements of the contacts. Performance and failure of several precious-alloy electrical contact materials are considered. **Edwin S. Bartlett,** in *Proceedings of the Symposium on Long Life Hardware for Space*, v. 1, 1969, 27 pp. Marshall Space Flight Center and Huntsville Section, American Society for Quality Control.

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# Views & Previews

### *Your Third Set of Teeth*

False teeth may no longer be the kind you put beside the bed at night. Instead, missing teeth may be replaced by implants that become as firmly fixed to the jaw as natural teeth. At least that's the promise of the early returns on research using a new concept in artificial teeth.

As explained by Thomas D. Driskell, the Battelle-Columbus scientist in charge of the study, the new teeth will be implants that look much like natural teeth: but each of them is composed of a conventional artificial crown, a root structure made from high-density alumina ceramic, and a metal center post that holds the crown and the root together.

The key to the development is the alumina root. Besides providing a biologically inert foundation, the material also furnishes a surface that is receptive to bone-producing tissue. Adherent growth of this tissue on the root surface bonds the tooth firmly and permanently into the surrounding bone.

The three-part configuration has given the designers much more latitude than would be possible if the tooth were cast from a single piece. In particular, using the conventional crown let them take advantage of an existing technology; all that was necessary was to adapt an item that is widely used in dental therapy. Moreover, Driskell points out, subsequent dental repair and restoration work on a composite tooth implant should be much simpler than if it were a single piece. If the crown is damaged, there's no need to replace the whole tooth; the crown can be removed and a new one slipped onto the post.

Experience with the Battelle development to date has been limited to implants in Rhesus monkeys, but the results are encouraging. More than 50 implants that have been put in place during the past 9 months are holding up well. The implanted teeth withstand loads that are comparable to those imposed on natural teeth, and tissue reaction has been favorable. Present plans call for some 20 more implants in monkeys. The clinical program is directed by Dr. George W. Greene, Jr., oral pathologist at the State University of New York at Buffalo.

Current interest is focused on single unit replacements for extracted teeth immediately following extraction. The implants will probably not benefit persons already wearing dentures, or those suffering from considerable deterioration of the jawbone.

Implanting involves three steps: (1) the vacated socket is modified to accommodate the implant, (2) the composite, minus the crown, is force fitted into the cavity, and (3) the crown is attached rigidly and aligned on the metal center post, and then cemented onto the root structure.

The research program is sponsored by the U.S. Army Medical Research and Development Command's Dental Research Division, headed by Colonel Milton J. Knapp.

### *Computers Move IAC's Forward*

The computer is moving to a new part of the information firmament — the information analysis center (IAC). The popularity of these centers is based on their ability to tap their holdings quickly for information in the subject area under study. Now, the availability of mass memories in computers allows the huge amounts of information and data held by IAC's to be stored in computerized systems.

The IAC's at Battelle-Columbus work this way: Information — limited largely to current developments — is stored as extracts on 5 x 8-inch cards. The extracts are taken mostly from such sources as reports, journals, and books; correspondence, interviews with leaders in the field, papers, and talks are extracted also. These items are chosen and processed under the direction of qualified scientists and engineers. Clue words, i.e., words that characterize the contents of the extracts are underlined. A copy of the extract is filed under each clue word, thus providing multiple entries to a subject area. The searcher need only go to the appropriate file drawer, remove the cards related to his subject, and scan them quickly. The information, selected and treated by his peers, is right in his hands.

However, card files seem to be on their way out. Implementation of a new system design, called BASIS-70 (Battelle Automated Search Information System), is bringing IAC's into the computer age, according to W. David Penniman of the information analysis group. Phase I is already operational and several centers are using the system. When completed, it will make the centers' information available wherever view-screen/typewriter terminals are tied into the IAC's time sharing computer. Information and data, stored in the computer memory instead of in file drawers, will be picked and prepared as before. However, life will be easier for the searcher. He can ask the computer for the information or data he needs by feeding in clue words. The IAC, using a computer for storage and retrieval, will be handier, faster, and possibly more efficient. The computer will communicate by a simple, easy-to-use question answer technique that minimizes difficulties, even for the novice, in using the system.

As described by John B. Fried and Burton H. Went, Jr., who are guiding the development, the user will be able to retrieve the available information either on a view screen, as typed copy, or in both forms. When viewing on the screen, he can edit the copy electronically so that only what he considers pertinent will read out. When further searching is necessary, a thesaurus, which is supplied by the computer, can be scanned for more leads. With experience, the technique for tapping the information holdings can become quite sophisticated. In the meantime, all extracts that the user wants to get his hands on can be collected electronically and printed at one time after the search is concluded. Among other useful services supplied by the system is one where the searcher can get the computer to analyze and combine data, and read out the resulting information in the form of graphs or tables.

Dave Penniman points out that this system can be adopted for any of a variety of situations where storage and retrieval of information or data are important — for example, where large quantities of management records, equipment files, descriptive catalogs, and personnel folders are reviewed frequently. He also notes that indexes can be set up to facilitate entry into extensive manual files that are already operating.

### *Neutron vs. X-Radiography*

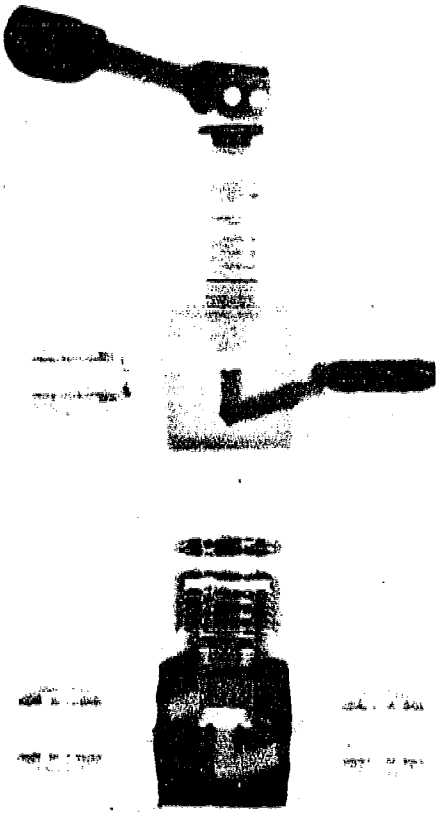
If X rays don't work, try neutrons. Indeed, neutron radiography is proving itself as a highly useful companion to X-radiography for visually penetrating opaque materials.

Neutron radiography complements X-radiography because it is effective with many materials that are either more or less opaque to X rays than to neutrons. Materials become more resistant to X-radiation as the atomic numbers of their major elements rise; heavy elements like lead are almost opaque to X rays. The case is quite different with neutrons; atomic numbers have little relationship to the attenuation of neutrons. Light elements like hydrogen, lithium, and boron are quite opaque to neutrons. On the other hand, neutrons pass freely through such heavy elements as tungsten, lead, and uranium as well as through lighter elements like aluminum, zirconium, and tin. With neutron radiography it is possible to differentiate even water, alcohol, and boric acid.

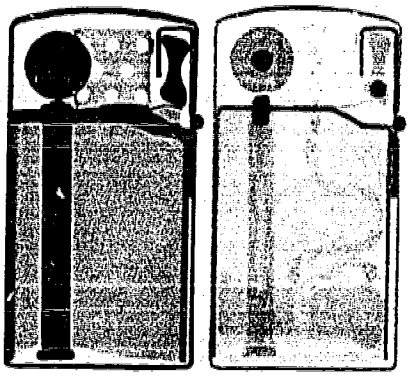
Neutron radiography calls for a neutron source (a reactor, radioisotope, or

neutron generator), a collimator to focus the stream of neutrons, and a conversion screen that is activated in proportion to the number of neutrons that strike it. In most cases, the conversion screen is needed to change the neutron beam to a form of radiation, such as electrons, alpha particles, or light, that can be used to expose film or to provide a signal to some other image-recording device.

According to Joseph W. Ray, who directs work on neutron radiography, studies on this technique are well advanced. Battelle-Columbus research has included programs on various types of neutron sources, on collimator and imaging systems (including television), and on using the technique for various purposes.



**Brass Valve.** The radiographs display the merits of the two techniques. The neutron radiograph (above) clearly shows the Nylon handle and gland seals (above and below the spring) and the water in the flow channel (below and to the right of the valve seat), which are not visible in the other radiograph



**Cigarette Lighter.** The photos illustrate how the two types of radiography complement one another. X rays (left) show up almost all of the metal parts. Neutron radiography reveals the cotton filler material, wick, and flint and a few other metal parts, even the spring configuration can be seen inside the metal tube supporting the flint

### *STOL: Rx for the Short Haul*

Short-haul air transport is in bad shape. Delays in takeoff and landing have more than doubled transit time on some flights. If the trend keeps up, it will be easier to drive than to fly from Boston to Washington, and we know driving is no picnic.

Short takeoff and landing (STOL) aircraft, requiring only 1,500 to 2,500 feet of runway, might relieve much of the problem. (Runways for conventional aircraft range from 6,000 to 10,500 feet.) If the STOL concept were accepted and a dispersed network established, the short-haul passenger could enjoy vastly improved service and large new market areas could have connective transportation that previously has been denied them. However, considerable study is needed to map out the best way to attack the problem.

These points were recently made by John K. Wetherbee of Battelle-Columbus in a presentation to the Second Annual National Aviation Planning Review Conference in Washington, D.C., in which he outlined the potential of STOL, particularly in the crowded Northeast Corridor where congestion has become critical.

Wetherbee pointed out that there is no doubt about our ability to build an aircraft to take off and land in a short distance; the Wright Brothers did that. The problems arise with the tradeoffs and compromises needed to get a successful STOL under way. For example, should the approach be to commission a full-blown system with many links and terminals in both hubs and suburbs? This could provide maximum benefit, but it would be extremely costly and hard to do.

Or, should the system start with a few terminals, small operators, and off-the-shelf aircraft, and then be allowed to grow by normal evolution? This might be more feasible technically and economically, but would potential operators take the risks to make the system grow? Or, are separate STOL ports the way to go at all? Although these would provide maximum close-in service, might it not be simpler and more realizable, at least in the near time, to operate from stub runways in existing airports that would be set up to use air and ground space apart from the conventional traffic pattern?

These kinds of questions have to be studied systematically. Much of the information needed to reach answers might exist already in the hands of air carriers, aircraft manufacturers, and research facilities and institutions. But knowledge beyond this is necessary. The combined efforts of an experienced systems team are required to map the attack on the problem, to integrate information where it already exists, and to pinpoint the areas where research or tests are needed to augment present knowledge. An analytic approach must be combined with a well-planned, controlled test program.

Positive government leadership will be necessary if these problems are to be solved. STOL is one possible approach with great potential; there are others. But clearly, the short-haul transportation problems must be faced. Fast, convenient transportation in the crowded corridors of the U.S. is a must for the continued health and growth of the American economy.

### *Martin on Battelle Board*

Clair E. Fultz, chairman of the Battelle Board of Trustees, has announced the appointment of William McChesney Martin, Jr. as associate member of the board.

Martin brings to the Battelle board some 40 years of experience with financial and governmental organizations. Recently he completed an unprecedented 19 years as chairman of the Federal Reserve Board. During his career, Martin became president of the New York Stock Exchange at the age of 31. After military service in World War II, he was named successively board chairman of the Export-Import Bank, assistant secretary of the U.S. Treasury, and U.S. executive director of the International Bank for Reconstruction and Development.

Lately elected to the board of International Business Machines Corporation, Martin is chairman of the board of trustees of the Berry Schools, and a trustee of Johns Hopkins University and of the Foreign Service Educational Foundation.

The Battelle board comprises 6 trustees and—with Martin's appointment—2 associate trustees. In addition to Fultz, who is president of Huntington Bancshares, Inc., the trustees are Dr. John A. Wheeler, professor of physics, Princeton University; Gerald B. Fenton, retired Columbus businessman; Dr. Sherwood L. Fawcett, Battelle president; Dr. John R. Pierce, Bell Telephone Laboratories; and Dr. B. D. Thomas, former Battelle president. Dr. Roger Adams, retired chairman of the Department of Chemistry and Chemical Engineering, University of Illinois, is an associate trustee.

### *Golden Path to Heterojunctions*

A large number of semiconductor devices are based on the creation of a p-n

junction within the semiconductor material. Junctions — interfaces between electron-poor (p type) and electron-rich (n type) regions — give semiconductors many of their valuable electrical characteristics. Most junctions used today are *homojunctions*, which are obtained by altering a single semiconductor material, such as silicon, by doping (poisoning) it. Doping with boron or indium, for example, will produce p-type regions; arsenic and other materials may be used for n-type regions. *Heterojunctions*, which are employed much less frequently, are prepared from two different materials—e.g., germanium on gallium arsenide — that serve as the p and n regions.

The difficulties of successfully mating diverse materials sharply limit the availability of devices with heterojunctions, but such junctions are of great interest because they promise new types of devices with many novel uses. Typically, the interface between the two materials is flawed by microscopic imperfections that keep heterojunctions from achieving anything close to their potential.

According to Dr. Y. F. Chang of the electronic materials and devices group at Battelle-Columbus, the problems of interfacial imperfections in heterojunctions may soon be solved, if the promises of his current research on germanium-gallium arsenide heterojunctions are borne out.

The technique that is being developed works like this. An alloy of gold and germanium is melted onto the surface of a gallium arsenide single crystal. The molten metal is then cooled slowly under painstaking control. As cooling proceeds, the germanium slowly precipitates out of the melt and deposits on the surface of the gallium arsenide in a single-crystal layer.

Metallographic examination shows that the interface between the germanium and the gallium arsenide produces a true heterojunction. The surfaces are free from defects and are intimately mated along a single plane.

The success of this technique stems from two factors: (1) the attainment of near-equilibrium conditions of deposition — assuring a single crystal of germanium, and (2) gold's ability to keep microcrystals of gallium arsenide from reforming at the germanium-gallium arsenide interface.

Gold is particularly useful here because its properties with regard to alloying with gallium arsenide are unique. Any metal that can be used to alloy and deposit the germanium will also dissolve some of the gallium arsenide. However, only gold is known to allow a germanium layer to form without precipitating the dissolved gallium arsenide as well. This is the heart of the technique. If gallium arsenide precipitated from the melt, the single-crystal interface layer would be contaminated. The result — no usable heterojunction.

Dr. Chang believes that this technique can be developed to deposit germanium or silicon on many III-V or II-VI semiconductors in like manner. This would open the way to improving the properties of a wide range of semiconductor devices.

### *BMI Receives NSPE Award*

Because of "its record of advancement and improvement of the engineering profession through development and use of forward-looking engineering employment practices in accord with professional standards," Battelle Memorial Institute has received the 1970 Industrial Professional Development Award of the National Society of Professional Engineers.

Nominated for the honor by the Ohio and Washington Societies of Professional Engineers, the final selection of Battelle was made by the NSPE Industrial Award Committee. Representatives of both Battelle-Columbus and Battelle-Northwest Laboratories participated in a special ceremony at which Battelle president and professional engineer, Dr. Sherwood L. Fawcett, accepted the award. This presentation took place recently at the Annual Meeting in Portland, Oregon.

The award committee considered engineering employment practices relating to registration, education and technical training, membership in societies, engineers as authors, working conditions, utilization, titles, engineering/management communications, indoctrination, salary plans, merit review and job evaluation systems, and the "dual ladder" program of promotion.

### *A New High in Marijuana Research*

Although marijuana has been around a long time, research on this drug entered a new era in 1966 with the synthesis of the delta$^8$- and delta$^9$-tetrahydrocannabinols (THC's) — components of marijuana that reproduce the psychic activity of smoke from the whole plant. However, scientists haven't been able to find out how these THC's work in the body, because the compounds disappear very soon after they are ingested.

Now it appears that Dr. Edward B. Truitt and his Battelle-Columbus research team have made a significant breakthrough in solving this puzzle. On studying the blood and liver of animals treated with THC, they have found a new substance that produces marijuana-like effects when it is isolated and injected into animals. Moreover, Dr. Truitt and his associates have successfully synthesized the new product from delta$^8$-THC. These achievements were realized in research for the Center for Narcotic Addiction and Drug Abuse Studies of the National Institute of Mental Health.

The new substance, identified as 11-hydroxy-trans-delta$^9$-tetrahydrocannabinol, appears to be a metabolite that is produced by the action of certain nonspecific enzymes in the liver. This is the first time that a derived metabolic product has been found to cause marijuana actions, and its presence might be the reason that THC's cause effects that are characteristic of marijuana even though the compounds disappear so quickly in the body. In other words, the THC's themselves may be inactive, but they may bring about the marijuana-like actions indirectly through their metabolic conversion product. Also, analysis for the new metabolite may provide a better means of identifying the use of marijuana.

The metabolite was isolated from blood and liver preparations by thin-layer and gas chromatography. Mass spectrometry and nuclear magnetic resonance furnished the data needed to define its chemical structure. The marijuana-like effects were demonstrated using the synthesized compound in rats.

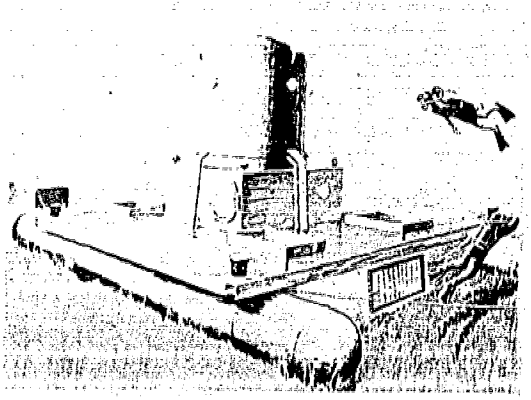
### *Tektite II and the Mini-Habitat*

The most ambitious U.S. "Man in the Sea" program yet is now in progress. Known as Tektite II, it got under way April 1 and will continue for 7 months at a spot off St. Johns, one of the Virgin Islands.

Under the management of the Department of the Interior, the program involves some 60 engineers and scientists including 5 women. They work in teams of from 2 to 5 members to complete various experiments on the ocean bottom at depths ranging from 50 to 100 feet. Missions run from 2 to 4 weeks.

Two habitats house the teams during their stay underwater. The first is the so-called "dual can" habitat (a double chamber connected by a corridor) that was used in Tektite I. It has been refurbished and is being used again at the same site.

The second habitat, the new Mini-Habitat (see sketch), has been placed on



the sea bottom at a depth of 100 feet. As its name suggests, this unit is considerably smaller than the dual-can structure, and also is much more spartan in its amenities. It consists of a barge, with floodable pontoons, that carries the living quarters—one 8-foot-diameter room and an ambient-pressure wet room. During July, the Mini-Habitat was towed to the chosen site and ballasted. The pontoons were carefully flooded so that the barge would sink to a predetermined level. Then, the habitat was pulled the rest of the way to the bottom by winches attached to concrete clumps.

Divers working in the Mini-Habitat breathe a 93 percent nitrogen-7 percent oxygen mixture that is piped through an umbilical from the support ship located topside. Other umbilicals supply low pressure air, oxygen, fresh water, electrical power, communications, and instrument readout. An eighth line permits personnel on the support ship to sample gases in the habitat atmosphere for direct monitoring purposes. The living quarters are furnished with a microwave oven, hot plate, small refrigerator, and freezer. Also, equipment is provided to cool and dehumidify the atmosphere and to scrub carbon dioxide from the breathing mixture.

The Mini-Habitat was designed and fabricated by the Worldwide Development Corporation, with Battelle-Columbus engineers monitoring the work. The Battelle team, headed by David E. Adkins, and including Donald W. Frink, Arthur J. Coyle, Jerry A. Henkener, and Ronald D. Brubaker, also has designed and assembled support-ship supply systems and advised on the sizes and capacities of umbilicals. Dave Adkins is participating with Ian Koblick, marine scientist and Tektite II aquanaut, in the first mission in the Mini-Habitat for a duration of 2 weeks on the bottom.

### *Light Back at You*

It's hell to drive on a rainy night, isn't it? The road becomes one big black open hole. You can't tell one lane from another, or where the road stops and the berm begins. Lights from the roadside or oncoming cars only add glare to the problem. You'd think they'd do something about that, wouldn't you?

There are reflectors for lane lines and center lines that work pretty well — in some places. The trouble is that these stick up as much as ¾ inch from the road surface. This is O.K. in warm country, but not up north; you get one summer's use out of them, and then after the first snowfall, a plow comes along and clips them off. They're pretty rocky to drive over, too.

Battelle physicists Daniel R. Grieser and Charles E. Moeller are working on a different idea for the Federal Highway Administration. They're designing reflector strips that are only ⅛ inch thick. Inside the strips will be special reflectors — based on the principle used in the mirror that the Apollo 11 crew placed on the moon to reflect laser beams back to their source on earth.

This kind of reflection — called retroreflection — is achieved by using corner reflectors, which are mirrors set at right angles to one another. When a light beam strikes one mirror, it is reflected onto the surface of the other mirror and then directly back to the source of the light — regardless of the angle at which the corner reflector sits. An ordinary mirror would reflect the light away from the source, unless the mirror was perpendicular to the beam.

What Grieser and Moeller want to do is make thin plastic strips with a smooth upper surface and a bottom surface that consists of thousands of these retroreflectors. When an auto headlight beam strikes the upper surface of the plastic, it will be deflected down to the array of corner reflectors. These will bounce the light beam right back to the surface of the plastic and on to the driver of the car.

The strips can be as thin as they are because the plastic selected has an index of refraction close to that of water. Thin strips are likely to become badly scratched in service, but because of the match in refractive index, wetting the strips has the effect of polishing them good as new. Thus, the wetter the road, the better the strips work.

Grieser and Moeller expect their strips to provide good visibility of lane lines and center lines for hundreds of yards ahead — even when the road is completely covered with water.

## Group Research

### *Forging Powder Metallurgy Preforms*

The idea of using powder metallurgy (P/M) preforms instead of cast and wrought billets as inputs for hot forging was conceived some three decades ago. Interest in employing such preforms is growing rapidly; however, technology has not kept pace. Though some companies have done research in this area, broadening the application of this forging process on a production basis calls for additional data. Metallurgists at Battelle-Columbus propose to conduct an investigation that will provide the data needed.

The forging of P/M preforms requires these basic steps: (1) combining powdered materials to give a preform with the desired composition; (2) shaping the preform under pressure; (3) sintering it; (4) heating it to the forging temperature; and (5) finish forging the part. The process omits three steps that are necessary in conventional forging — preforming the billet, blocking it, and trimming the flash after finish forging.

There are several advantages to forging P/M preforms. Besides avoiding the cost of these three conventional-forging steps, it virtually eliminates the usual scrap loss. Further, the final products show less directionality of properties in general and better reproducibility of mechanical properties.

According to Harold J. Henning, who will lead the proposed research program, plans call for undertaking six tasks over a period of 3 years. These are expected to provide data that will allow the forging of P/M preforms to be done on a broader scale while greatly minimizing the need for further development studies. The six tasks will cover:

1. The effects of preform characteristics and forging variables on forgeability of the preforms.
2. Guidelines for designing preforms that will yield the highest quality forgings.
3. Process development factors such as temperatures, pressures, transfer times, and lubrication.
4. Data for predicting quality control requirements and reproducibility of products.
5. Machinability ratings for P/M preform forgings, for comparison with those of wrought bar stock.
6. Heat treating methods, to compare the response of P/M preform forgings with those of conventionally formed products.

It is expected that data provided by the study will benefit companies in the forging and P/M fields by enabling them to improve production and expand markets. Users of parts forged this way will get information that will permit them to specify materials and to design parts with greater confidence, thus leading to an accelerated demand for such items. The results also will be useful to producers of powder and manufacturers of equipment, for similar technical and economic reasons.

Presentation of the proposed program to potential sponsors is planned for late August.

### *A Hot Study of Electroslag Refining*

Electroslag refining (ESR) of metals and alloys, like vacuum arc remelting (VAR), is used today as a batch-type operation to produce high quality materials, particularly such iron-base materials as bearing, tool, and high strength steels. In both processes the metal is first cast in the form of electrodes. In VAR,

the consumable electrodes are remelted in vacuum using arc heating. In ESR, the consumable electrodes are remelted at atmospheric pressure by molten slag that is electrical resistance heated. Purification and solidification of the metal can be controlled to about the same extent in the two processes; consequently, both now compete as means for producing large ingots commercially.

For both VAR and ESR, it is a long road from the original material to the end-product. The ingot produced by remelting must be forged or rolled into a billet; the billet is then forged or somehow worked into a preform, which is finally fabricated. Suppose that using ESR, we could go directly from melting to a semifinished shape? Obviously, costly, time-consuming steps would be avoided. Battelle-Columbus metallurgists are proposing a study to attain that goal.

In ESR, as in VAR, melting is done in a water-cooled metal crucible. In ESR, however, one end of the electrode contacts a slag layer that floats on the molten pool of refined metal. Heat generated by the slag's electrical resistance makes the slag hotter than the submerged part of the electrode. Drops of metal form and sink through the lighter slag; subsequently, the metal solidifies in the bottom of the crucible. The slag works beneficially in three ways: (1) it takes some impurities from the metal as the drops pass through; (2) it prevents direct pickup of contaminants, such as oxygen from the air, by covering the molten metal; and (3) it coats the crucible wall, and thus helps achieve a smooth ingot surface and high recovery of metal. The slag coating on the refined ingot is removed easily.

It seems quite feasible to arrange for the ESR molten metal to solidify in crucibles or molds shaped to provide ingots or preforms with various configurations. In the case of a hollow cylinder, for example, the cavity could be achieved by positioning a mandrel in the crucible; electrodes could be dispersed around the mandrel to supply melted metal evenly.

The proposed program also will consider the practicabilities of preparing preforms by continuous ESR melting. This would be investigated using a bottomless crucible; the cylindrical preform would be lowered as the melting and subsequent freezing proceeded.

Although the areas for investigation are not novel, extensive research is required to provide a basis for producing preforms by ESR. The numerous "degrees of freedom" that make varied uses of ESR possible also create difficulties for the investigators because of the many variables involved.

Basically, Battelle-Columbus specialists are planning to take a fundamental approach in this study. They seek to develop a thermal-metallurgical understanding of the process that will permit designing unconventional ESR units as well as improving conventional ones.

Toward this end, a 2½ year study is contemplated. A meeting to present the proposed program to representatives of interested organizations is being arranged for mid-August.

A. O. Hoffman of the Process Metallurgy Division, who will direct the study, indicates that the program will include:

1. Developing thermal data on such factors as power input and power modes (ac or dc), the requirements of the slag pool, the relationship of the metal pool size to the rate of metal solidification, and the effects of the slag coating.
2. Incorporating these data into a computer model for working out the relationships among various factors in melting and the quality of the product, so that specialized ESR units can be designed without further extensive studies.
3. Demonstrating the validity of these analyses by proceeding with the design, development, and operation of an ESR unit for producing hollow cylinders, a preform shape that is both attractive to the industry and difficult to make.
4. Proving out the structure (e.g., grain orientation, grain size, and homogeneity), workability, properties, and performance of preforms so produced.

The economic potential of this program could approach that of the development of continuous steel casting. Higher yields, lower capital investments, and reduced product costs are expected to result. Such a development will be of particular interest to fabrication shops and alloy producers.

# Professional Posts

Staff members recently named to professional posts include:

FREDERICK A. CRESWICK, technical program chairman, Intersociety Energy Conversion Engineering Conference, Society of Automotive Engineers.

DR. RICHARD S. DAVIDSON, member, Committee on Agriculture in Relation to the Quality of the Environment, Agricultural Research Institute, National Academy of Sciences.

WINSTON H. DUCKWORTH, chairman, Committee on Classes and Divisions, American Ceramic Society.

DR. CHARLES L. FAUST, chairman, Symposium on Fundamental Aspects of Electrochemical Machining, Electrothermics & Metallurgy and Electrodeposition Divisions, Electrochemical Society.

DR. SHERWOOD L. FAWCETT, vice president, and chairman of Section on Industrial Science, American Association for the Advancement of Science.

WILLIAM C. FINLEY, member, Forestry Advisory Council, State of Ohio.

DR. CURTIS M. JACKSON, member, Van Miller Award Committee, The Wire Association.

DR. ROBERT I. JAFFEE, chairman, Research and Technology Advisory Panel on Materials for Aircraft Engines, National Aeronautics and Space Administration; and member, Committee on a Distinguished Lectureship in Materials and Society, Metallurgical Society of American Institute of Mining, Metallurgical, and Petroleum Engineers and American Society for Metals.

EDWARD E. LAITILA, chairman, Urban Economics Committee, American Real Estate and Urban Economics Association.

ORVAL L. LINEBRINK, chairman, Meetings and Program Committee, National Conference of Standards Laboratories; and Instrument Society of America representative to the National Conference of Standards Laboratories.

JAMES P. LOOMIS, representative from the American Institute of Aeronautics and Astronautics on the Intersociety Planning Committee to establish the U.S. National Committee on Transportation Engineering.

DR. F. ROLF MORRAL, member, Advising Committee, Emilio Jimeno Technical and Metallurgical Institute, Spain.

A. GEORGE MOURAD, chairman, Study Group No. 1-25 on Marine Geodesy, International Association of Geodesy.

JOHN W. MURDOCK, member, Science Information Council, National Science Foundation.

LORAN S. O'BANNON, chairman, Past Presidents Council, American Ceramic Society.

CHARLES W. RODMAN, membership secretary, Acoustical Materials Committee, American Society for Testing and Materials.

# Appointments

**Frederick L. Bagby,** assistant director, sponsor and program development. He is responsible for generating new and expanded research programs and for developing support for them from industry and government on a contract basis. Fred has been manager of the Department of Mechanical Engineering. With Battelle since 1946, he has a long history of conducting and directing research in the various fields of engineering, with particular stress on aeronautics and astronautics.

**Richard J. Anderson,** director of research promotion, devotes much of his effort to developing more effective communications between Battelle-Columbus and business, professional, and government groups. This is an extension of his role as interpreter of scientific and technological research. He will continue to serve as assistant to the vice president, devoting part of his time to the programs of Battelle's affiliate organization in Australia.

**Edwin E. Graves,** administrative manager, sponsor and program development, is responsible for the administrative and budgetary control of programs related to maintaining sponsor relations and opening new areas of research sponsorship. His concerns extend to the development of new approaches and operational procedures for such services and to the strengthening of sponsor relations not associated with specific research projects.

**George M. McClure,** manager, Department of Mechanical Engineering. He carries the overall responsibility for managing research in the many sectors of mechanical engineering including the general areas of design and development engineering; solid and structural mechanics; and fluid and thermal mechanics. In his 21 years at Battelle, George has performed and directed research in the general field of structural mechanics, especially on pipelines, piping, and pressure vessels.

**Thomas J. Atterbury,** associate manager, Department of Mechanical Engineering. In his new assignment, Tom oversees research in the fields of applied solid mechanics, stress analysis, structural analysis, materials application, and fatigue of materials. Formerly chief of the Applied Solid Mechanics Division, Tom has guided theoretical and experimental stress-analysis studies, especially on pressure vessels and shell structures.

**Dr. Joseph W. Duncan,** associate manager of the Department of Economics and Information Analysis, has the responsibility of expanding Battelle-Columbus studies in the urban field. He has conducted such research for a decade, broken by service as Deputy Assistant Secretary in the U.S. Department of Commerce. In recent years he has directed Battelle's Urban Studies Center in Cleveland. Other fields of interest have been manpower trends, regional growth patterns, and urban socioeconomic problems.

**Dr. Charles W. Townley,** assistant manager, Department of Physics. He is responsible for activities related to technical and management development, and for administrative and personnel matters. Chuck has served as chief of structural physics research, and earlier as chief of chemical physics research. He has considerable research to his credit, particularly in nuclear and radiochemistry and in the application of radioisotope techniques.

**Arthur R. Duffy,** chief of applied mechanics of materials. He and his colleagues perform engineering studies that apply the principles of fracture mechanics and knowledge of materials properties to the design of fracture-safe piping, pressure vessels, and other structures. This group conducts research in all aspects of pipeline technology and on the storage and transport of cryogenic fluids.

**Robert J. Fiorentino,** chief of metalworking research, directs analytical and experimental studies on the development of metalworking systems; hydrostatic extrusion and forming; isothermal, incandescent rolling; precision and conventional hot and cold forging; conventional hot and cold extrusion, rolling, and wire drawing; metalworking lubrication; and the design of metalworking tooling and equipment for both laboratory and prototype production.

**James S. Glasgow,** chief of marine equipment engineering, guides the development of techniques and equipment for supporting life and performing work underwater. Broadly experienced in mechanical engineering and machine design, his group also performs research on automated product-inspection systems, biomedical devices and instrumentation, and the application of special materials such as the memory alloy, Nitinol.

**Dr. John F. Kircher,** chief of structural physics, supervises research in crystal growth and structure, surface science, and materials structure analysis, using such techniques as x-ray and electron diffraction, electron microscopy, ellipsometry, and electron microprobe analysis.

**David W. Locklin,** chief of combustion systems and air quality engineering. He directs a new division that is manned by staff members experienced in the fundamentals of combustion and the development of combustion equipment, with emphasis on the control of air pollution. The group's skills also cover the areas of air quality studies, atmospheric diffusion, incineration, and pollutant emission measurements.

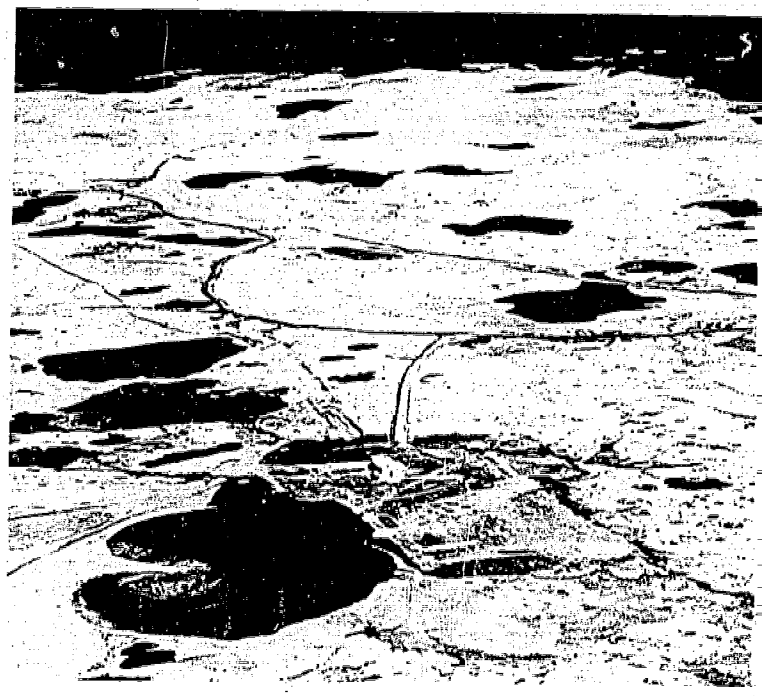
**Howard C. Meacham,** chief of mechanical dynamics, leads a group that specializes in vibration analysis and acoustical studies. This group focuses strongly on investigating dynamic phenomena such as those associated with machine tools, production machinery, and all types of vehicles ranging from golf carts to high speed passenger trains.

**Spencer A. Schilling,** chief of metals and minerals, electronics, and manufacturing economics research, guides studies involving diversification planning, new-product planning, marketing-strategy development, and venture appraisal relating to these and other fields.

**James E. Sorenson,** chief of applied solid mechanics, oversees the use of theoretical and experimental stress-analysis techniques and materials technology in research associated with the design of a wide range of structures. Important areas of application include offshore structures and pipelines, pressure vessels, aircraft and space vehicle structures, and nuclear reactor structural components.

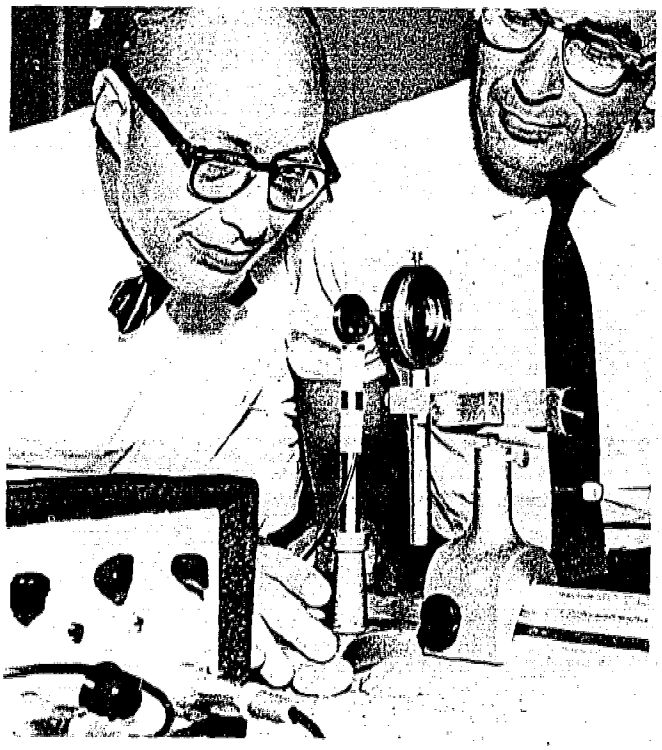
**Robert A. Stein,** chief of defense planning and engineering, a newly formed division in the Washington, D.C. offices. He and his associates are concerned mainly with planning, systems, and engineering studies that require close liaison with organizations located in the capitol area.

# The Research Scene



**Ecological Effects of Milrow.** What did an underground nuclear test—Milrow—of about 1-megaton yield do to life and the physical characteristics of the Aleutian island of Amchitka, located about 2,500 miles west of Seattle? The two photos, before and after the test, show how the lakes near surface ground zero (SGZ) were affected by the detonation 4,000 feet underground. As part of the test program sponsored by the Atomic Energy Commission, the Battelle-Columbus bioscientists have been guiding and coordinating the evaluation of Milrow's effects upon the island's ecosystems. The aims of the study are to establish (1) bases for predicting the effects of future tests, (2) methods of evaluating and documenting test effects on animals, plants, and their environments, and (3) recommendations of measures that will minimize the effects of any future nuclear test. Although the nuclear tests are designed to contain all radioactive materials underground, a major concern is the ability to predict what hazards an accidental release of radioactivity might create for man via the various possible food chains (e.g., plankton to fish to man).

According to Dr. Richard S. Davidson, program director, and Dr. James B. Kirkwood, technical coordinator for the bioenvironmental studies, preliminary postshot observations indicate that a small number of stickleback fish were killed by shock effects, but only in lakes near SGZ. No adverse consequences were immediately detectable on marine life such as sea otters, sea lions, fish, and sea urchins. There was some shifting of water courses on the island and also some damage to cliffs and sea stacks where birds nest in Spring and Summer. Data on the immediate postshot effects were gathered by bioscientists from Battelle, the University of Washington, The University of Tennessee, The Ohio State University, The Utah State University, The Smithsonian Institution, Cornell University, The U.S. Department of the Interior, and the State of Alaska. The same investigators are analyzing the data collected, and presently are gathering additional data to document any delayed effects of Milrow.



**Harnessing Lasers to Glass Production.** How is laser radiation converted to energy in glass? What forms does such energy take? These are important questions in the Battelle-Columbus program on the use of lasers in the glass industry. Critical in this investigation is a thermocouple to detect infrared radiation in the $CO_2$ laser beam and to measure the intensity of such radiation. Osmar A. Ullrich (right) designed and prepared a thermocouple that can sense infrared radiation within 25 microseconds. The thermocouple consists of crossed strips of silver and bismuth that are vacuum evaporated on glass. Here, Dr. John Robert Shewell, who heads the laser-use study, is positioning the device behind a 1.5-inch focal length lens that focuses the beam on the thermocouple junction.

**Predicting Blood Compatibility of Materials.** Finding materials that are compatible with human blood is a first-order need in developing devices that are to work with man's circulatory system. Predicting such compatibility is an important step in evolving appropriate materials. According to Dr. Carl J. Pennington, a valuable predictive index is based upon the adherence of blood elements to a material after it has been immersed in blood for a prescribed period. Shown here in remarkable detail is a candidate synthetic material after immersion; this specimen is being studied in research for the Artificial Heart Program of the National Institutes of Health. The appearance of platelets that have attached themselves to the fibers indicates that the material is only marginally blood compatible. The clarity of the photomicrograph demonstrates the usefulness of the scanning electron microscope in blood compatibility studies.

**BATTELLE MEMORIAL INSTITUTE**
**Columbus Laboratories**
**505 King Avenue**
**Columbus, Ohio 43201**

**OTHER BATTELLE LABORATORIES OR OFFICES:**

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The Columbus Laboratories of Battelle Memorial Institute perform contract research for industry, government, and other organizations. They provide the personnel, experience, and equipment to solve problems and generate basic knowledge in virtually all areas of science and technology.

Much of Battelle's growth has stemmed from the successful application of the multidisciplinary approach to research, in which specialists from different scientific, engineering, and other disciplines join forces to apply their in-depth knowledge to a problem.

At Battelle's laboratories in Columbus, Ohio, the research focuses on:

- the solution of highly specific and practical problems as well as theoretical explorations on the frontiers of science.
- the design and development of materials, products, processes, and total systems.
- information analysis, technical-economic and socio-economic studies, and marketing and management-planning research.

Battelle research has produced advances in highly diverse fields for sponsors large and small located in 90 different countries.

The staff at Battelle-Columbus includes approximately 1,400 scientists and engineers who are experienced in a variety of disciplines. Supported by an equal number of other personnel, they conduct research in specialized laboratories and other facilities housed in 35 buildings. Battelle-Columbus also operates research facilities at Duxbury, Massachusetts; Daytona Beach, Florida; and Long Beach, California.

Battelle Memorial Institute was established under the will of Gordon Battelle, last of his line, as a memorial to his family. The Battelles were among the first settlers of Ohio and were prominent in the development of the state's iron and steel industry. Operations began in laboratories that today are part of Battelle-Columbus; and corporate headquarters continue to be in Columbus. Other Battelle centers for contract research are now situated in Richland, Washington; Frankfurt, West Germany; and Geneva, Switzerland. Other research sites and offices are located throughout the world; the staff worldwide totals about 7,000.